VOL. XXXVII. — No. 10. OCTOBER 1960.

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Monthly Bulletin of the International Railway Congress Association

(English Edition)

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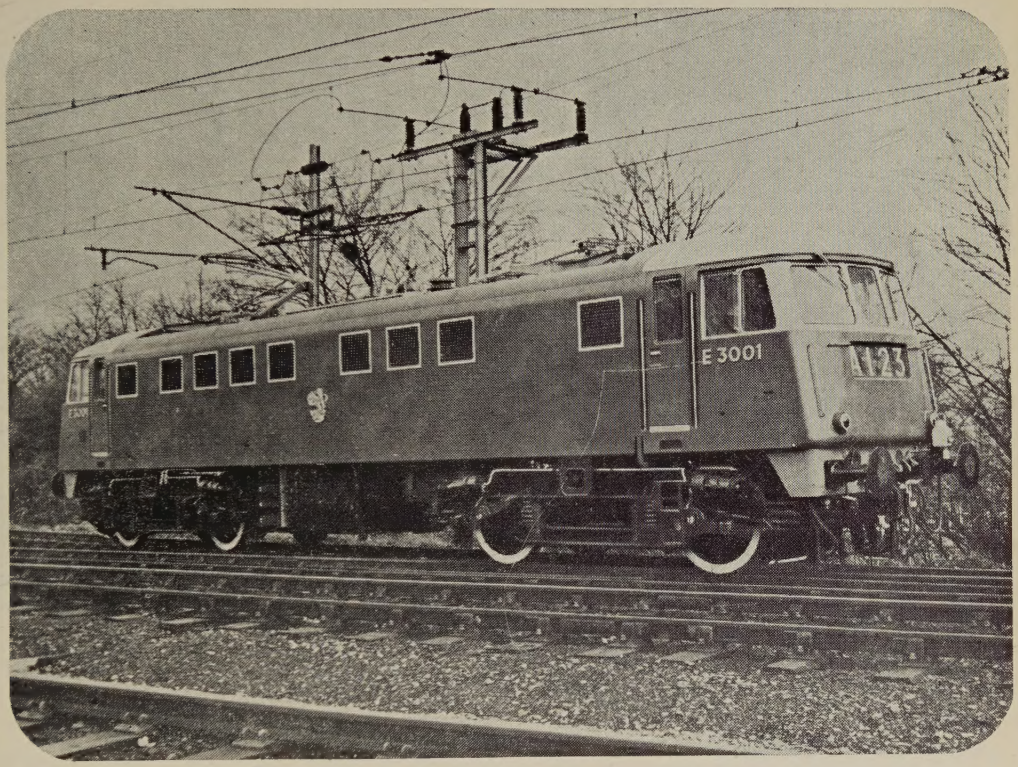

British Railways type "A" 3,300 h.p. 25 kV 50 cycle a.c. electric locomotive, one of 23 being supplied by Associated Electrical Industries Ltd., for service on the London Midland Region.

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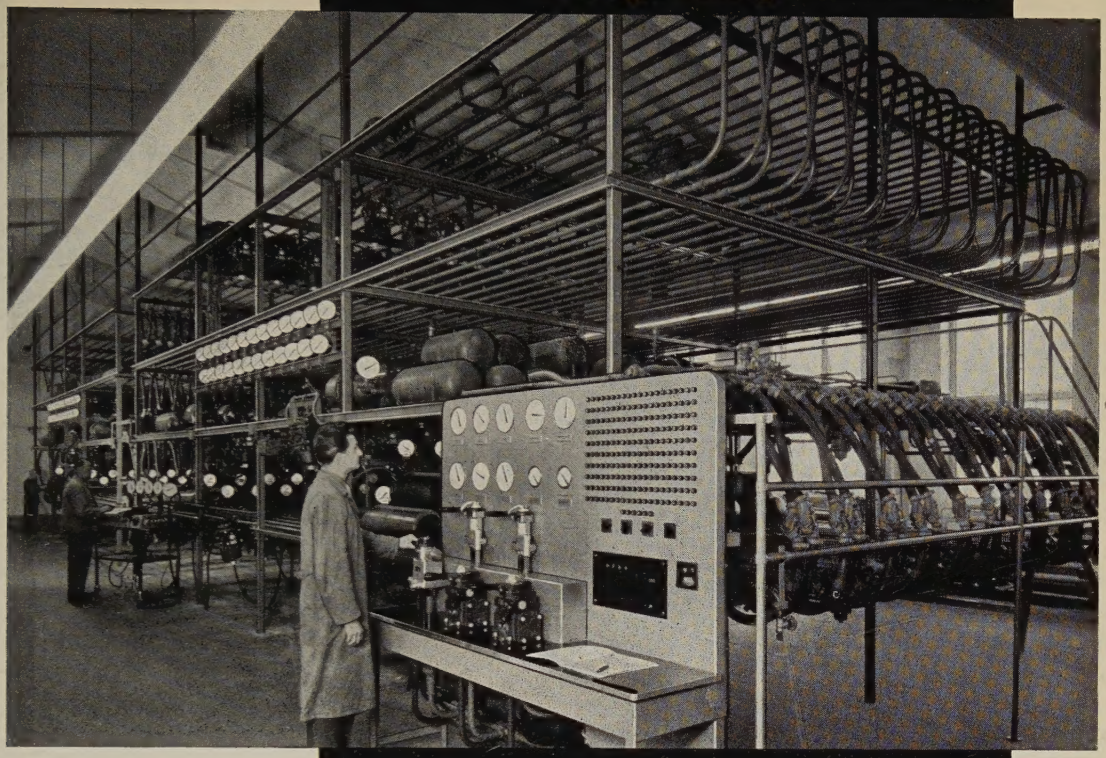

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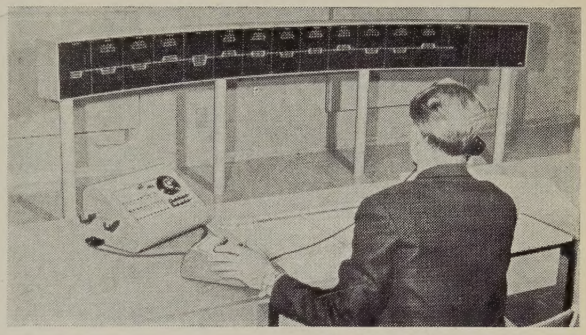
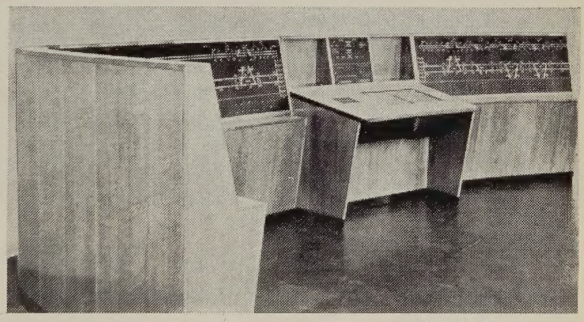


Swedish State Railways

— control buttons placed along the track on the track diagram.

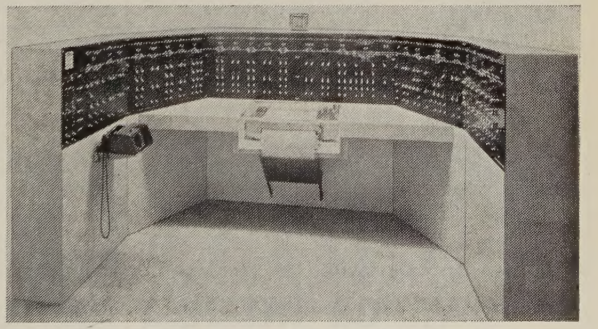
Train routes are established by simultaneous depression of two buttons, one at the start and one at the end of the route.



Danish State Railways

— control levers placed below the track on the track diagram.

Train routes are established by first positioning the point and signal levers and then pressing a button.



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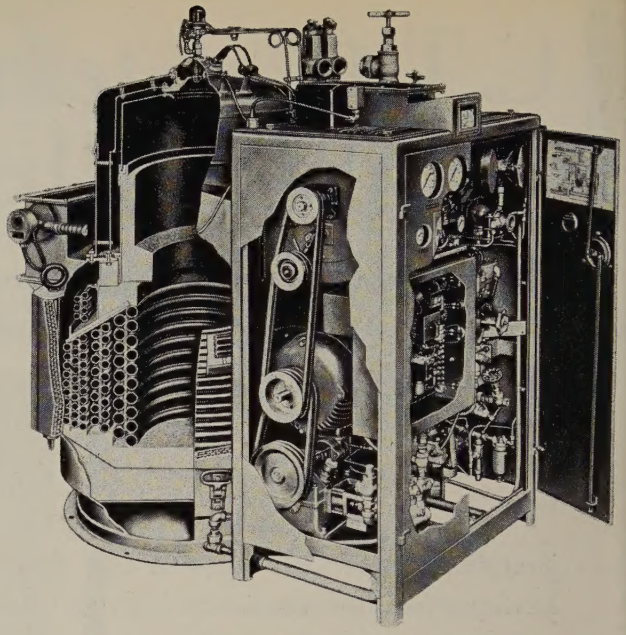

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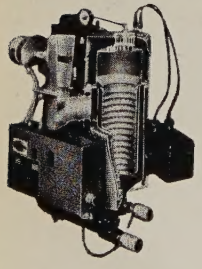

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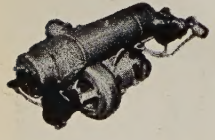

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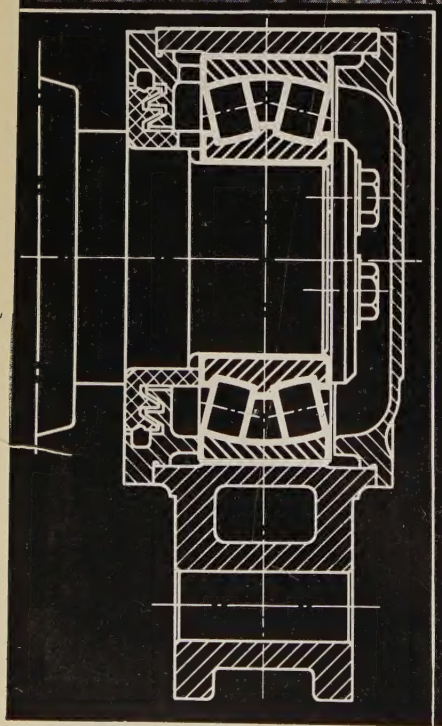

RAILWAY JOURNAL AXLE-BOXES

RIV

OFFICINE DI VILLAR PEROSA S. p. A. - TORINO

The pattern shown in the rail section above was produced by the photo-elastic method. A model of the section was cut out from a ¼" thick sheet of a transparent material, mounted in a frame at a tilt of 1 in 20 and loaded to represent service conditions. Polarised light projected through the model produces the stress pattern on a screen. The fringes (or bands) on the pattern join up points of equal shear stress. The actual value of the shear stress along any fringe is proportional to the number of fringes counted from an unstressed area or counted as they spread outwards from the regions of highest stress, as the loading is increased. The method is useful for the comparison of different rail sections and particularly for the examination of proposed new sections. It can be complementary to the measurement of strains in actual rails loaded in a special test frame.

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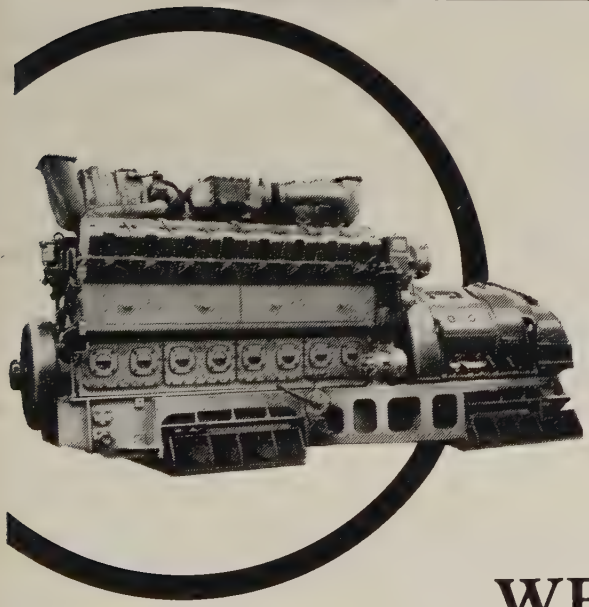

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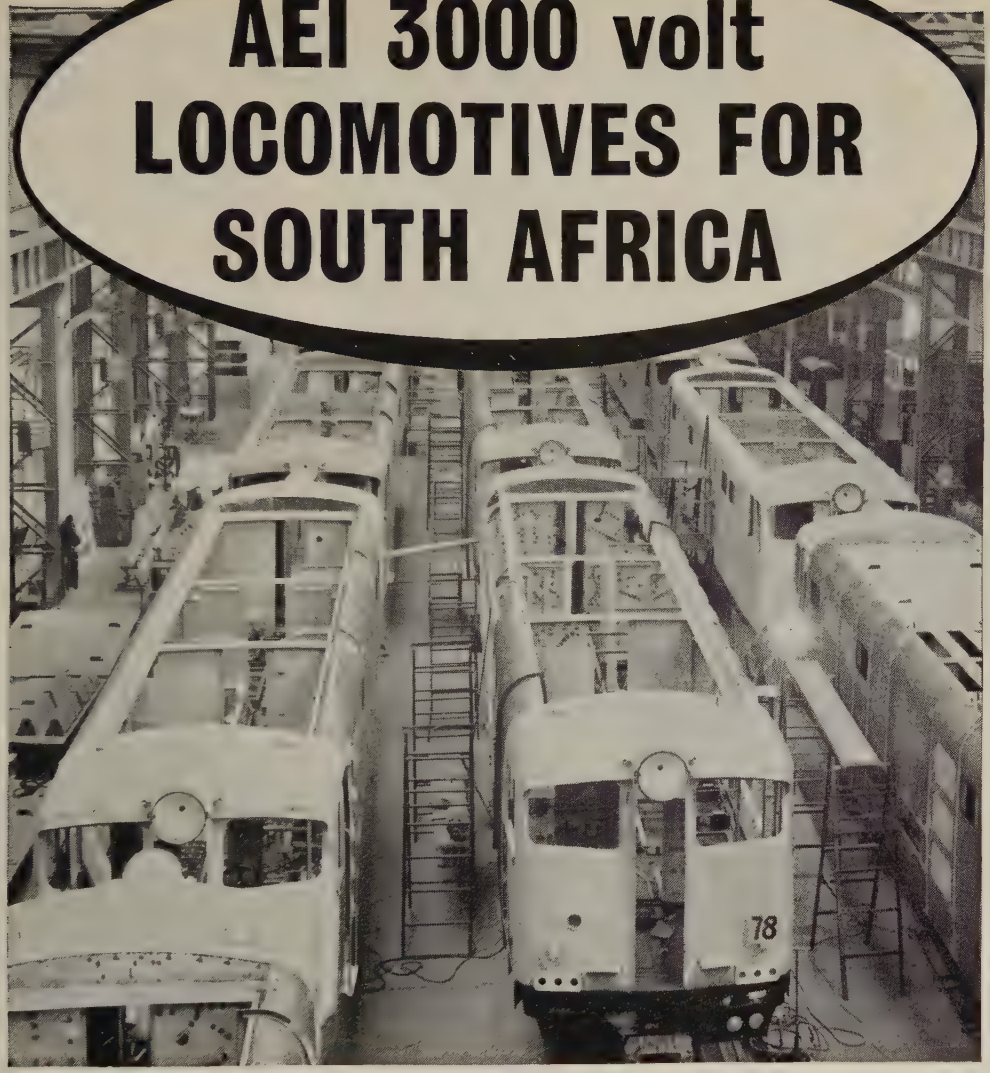

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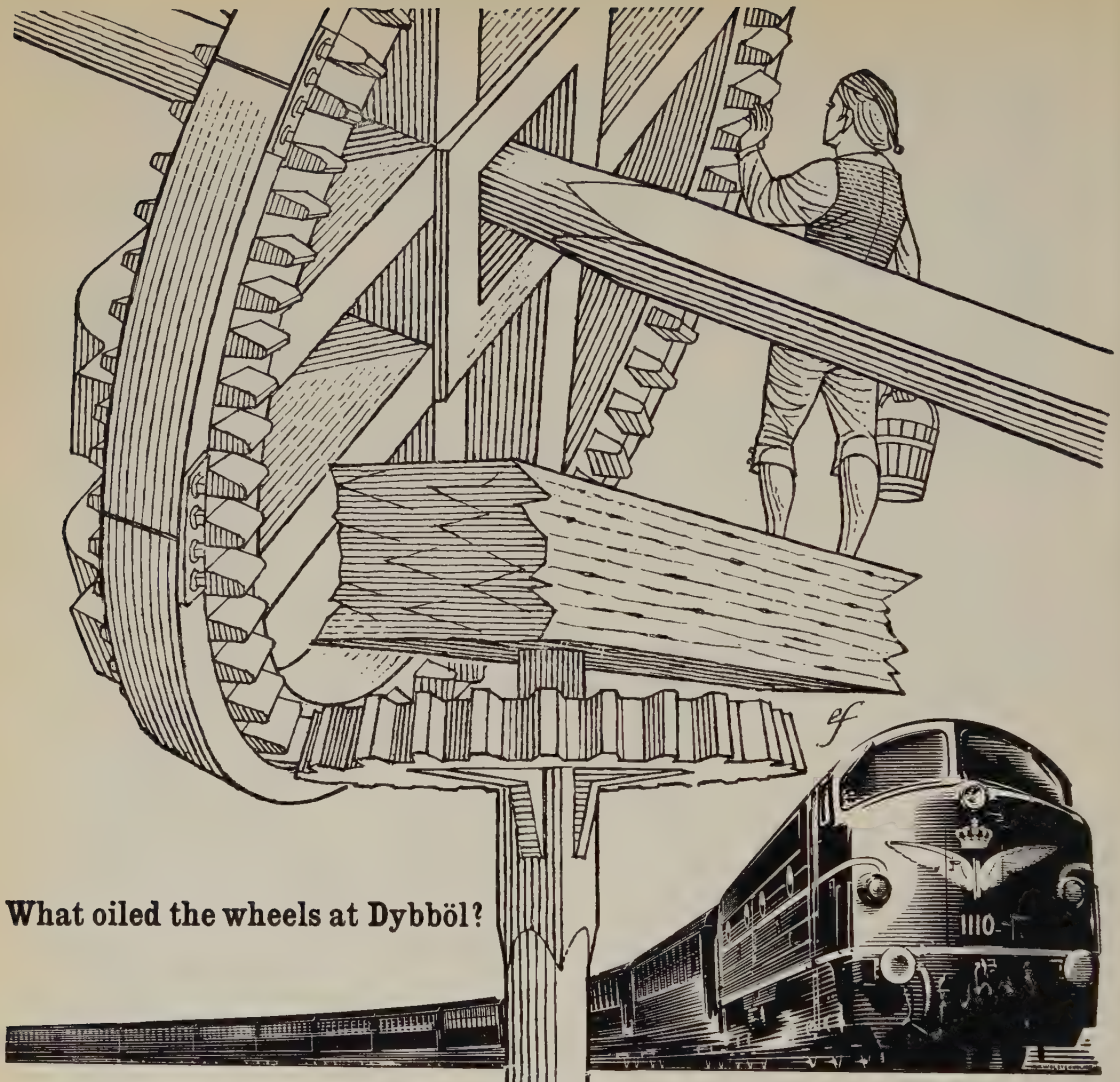

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BP protects all Danish Railways' General Motors diesel locomotives with world-tested products that have proved their superiority in railways service. BP Energol IC-D40 used in these engines is listed by General Motors EMD in their "Considerable Usage" category. It is exclusively used in the GM-Nohab locomotives.

BP Railway Lubrication Service

Bulletin of the International Railway Congress Association

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MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES : 19, RUE DU BEAU-SITE, BRUSSELS

Price of this single copy : 80 Belgian Francs (not including postage).

Yearly subscription for 1960 { Belgium . . . . . 700 Belgian Francs
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Vol. XXXVII. — No. 10. October 1960.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656 .254 (493)]

An original and inexpensive design of a centralized control operating cabin or post for electric traction on the Belgian National Railways,

by P. CHARLES,

Ingénieur civil, électro-mécanicien,

Ingénieur du Service d'Électricité et de Signalisation de la Société Nationale des Chemins de fer Belges, à Namur.

PLAN OF THE DESIGN.

§ 1. **Generalities.**

1.1. Object of the design.
1.2. Remote controlled operation system on the S.N.C.B.
1.3. Duties of the controller.
1.4. Advantages of remote control.
1.5. Layout of the cabin.
1.6. Original features introduced in the Namur cabin.

§ 2. **The way the cabin has been arranged in practice.**

2.1. State of the installation when brought into service.
2.1.1. Remote control operation.
2.1.2. Remote control signalling system.
2.1.3. Various other signalling system.
2.2. Extensions to be envisaged.
2.3. Layout of the buildings.
2.4. The way the illuminated diagrams have been made.
2.5. The way the desk has been set out.
2.6. The arrangement of the relay cabinets and those for the auxiliary services.
2.7. Lighting problems.
2.8. The processus of operating.

§ 3. **Relating to the system adopted.**

3.1. Particular features of the specifications.

§ 4. **Conclusions.**

§ 1. GENERALITIES.

1.1. The object of the design.

The object of the present report is to study the remote control operation of the substations and sectionalizing posts of an electrified railway system from a control post of original design and relatively low cost.

To begin with, let us place the new remote controlled operating post within the frame of the Belgian electrified system.

1.2. Distant operated substations network of the S.N.C.B.

Figure 1 shows the electrified lines of the S.N.C.B., when electric traction was

inaugurated on the Charleroi-Namur line (29th May 1959). This figure shows the locations of the substations and sectionalizing posts on the one hand, and the remote control operating posts on the other (underlined with a full line). The limits of the districts of the distant operated posts are underlined with dotted lines (1).

Each post is operated by a « controller ».

1.3. **Duties of the controller.**

Let us say to begin with that we wish to speak of the controller known in Belgium as « E.S. Controller » (E = Electricity — S = Signalling) in opposition to the « MA Controller », who deals more particularly with the electric rolling stock. The E.S. Controller in Belgium corresponds to the « Central substation » in France, the Grand Duchy of Luxembourg, etc. In what follows, we willingly drop the indication « E.S. ».

The controller is responsible for the substations, the sectionalizing posts and the overhead lines of a clearly defined part of the system (see fig. 2 for Namur).

The controller has to be kept informed of all that takes place in these installations. No movement in a substation or sectionalizing post can be made without his agreement : out on the line no breaker or switch can be operated without his order.

The advantage of this solution is that all orders concerning the fixed electric traction installations are given by one and the same person.

As he is aware of everything that takes place, the controller can easily take the necessary steps to assure the best feed to the overhead wire by a rational operation of his equipment. With this object in view, he has a special telephone circuit of the dispatching type, by which he can get into communication quickly with all the distant operated posts (substations and sectionalizing posts), the block posts and the stations. This circuit, known as the control circuit, enables the controller to obtain information quickly and rapidly carry out the operations of sectionalizing, repairs and maintenance.

Moreover, the controller is in contact with the dispatcher(s) or controller(s) of the electrified lines of his region, as well as with the controllers of other adjoining areas. The emergency circuits, with the telephones all along the track end at the dispatcher who by simply turning over a key can switch the conversation over to the controller. He can, if need be, be told of a failure to the overhead wire or be asked to cut off current urgently. This telephone can also serve as liaison between the controller and repair gangs of the overhead lines (1).

Finally, always by telephone, the controller can get into touch with the various suppliers of high voltage current. In Belgium, the men appointed to the controller's position are first grade foremen. They have risen from the grade of second grade of the specialised « overhead wire

(1) The dates the posts were brought into service were as follows :

Charleroi	middle of	1954
Antwerp	beginning of	1955
Ghent	on the	1.4.56
Brussels	end of	1957
and Namur	end of	1959

(1) It should be noted that the controller cannot call up a warning post on the line.

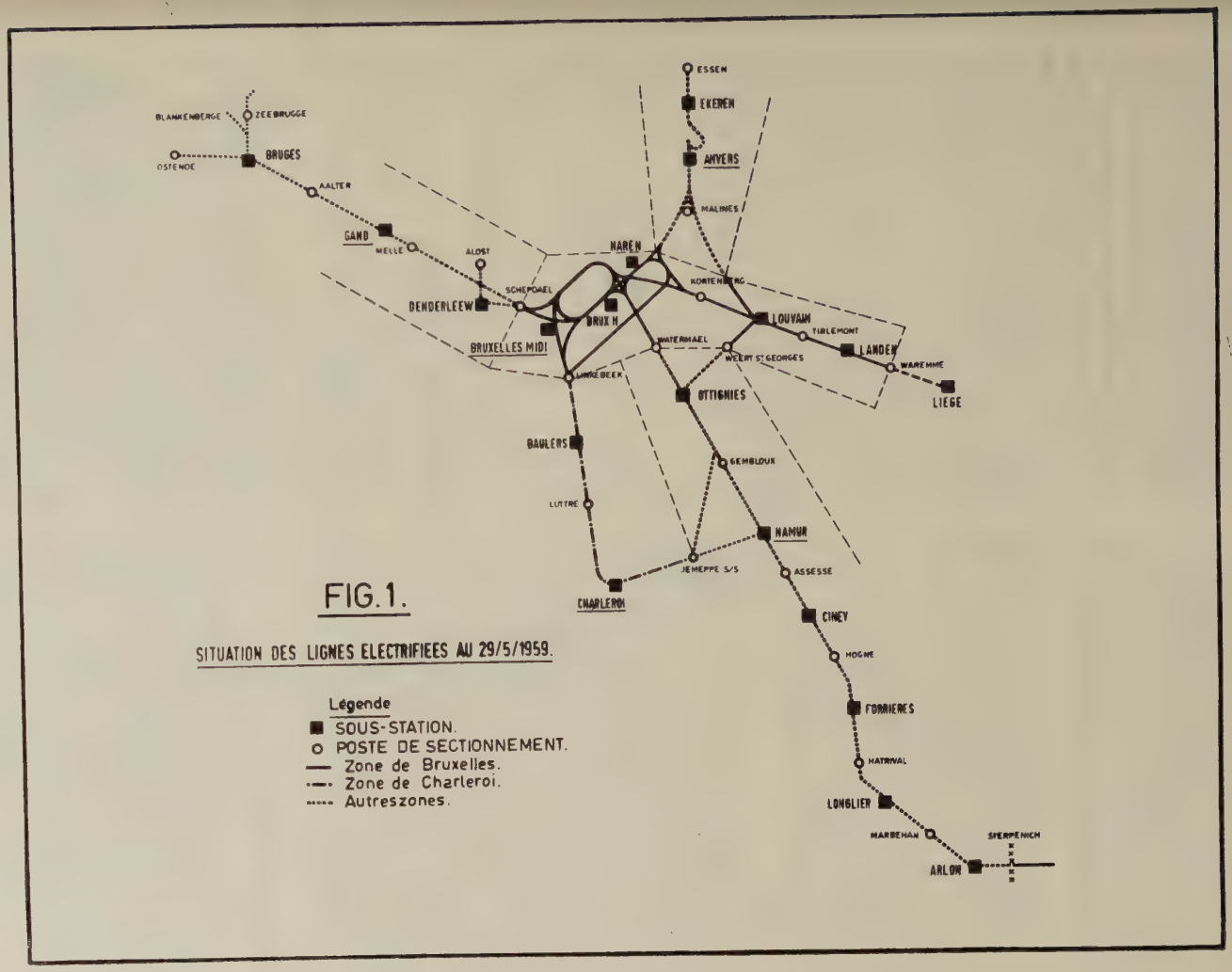


Fig. 1. — Position of the electrified lines at 29/5/1959.

N. B. — Légende = reference. — Sous-station = substation. — Poste de sectionnement = sectionalizing post. — Zone de Bruxelles = Brussels district. — Zone de Charleroi = Charleroi district. — Autres zones = other districts.

and substation » group which means that they are fully conversant with the installations for which they are called to assume responsibility.

1.4. **Advantages of remote control.**

Remote control enables the controller to control directly many apparatus in the substations and sectionalizing posts, and to take action quickly without going through any intermediary.

Consequently, the efficiency of the controller is appreciably improved because many orders by telephone have been replaced by operating the switches and keys.

The gain in time which results can be very valuable, especially when anything goes wrong or in the event of damage. Moreover, the concentration at one point of the operating and signalling of many installations shows a great saving in staff.

The maintenance staff is adequate and the hours of duty can be selected so as best to concentrate the personnel available when required by important work.

Remote control is now so reliable in functioning that it is applied to all installations, even very important ones, such as for example a substation with 4 power sets (3 000 kVA) and many feeders.

1.5. **The layout of the posts.**

All these installations other than at Namur have been carried out following the method so far adopted on electrified railway systems. The controller has before him a very large diagram which shows to a reduced but practical scale the signalling and means of operation to be found in the various posts served. The diagram is of the type with the lights normally extinguished with lamps to show incompatibility in the levers.

When the installations under control multiply, the diagram assumes immediately a considerable size, the greater as it is desirable to add to it the plan of the sectionalizing of all the electrified lines (a solution frequently adopted is to leave the secondary tracks off the diagram).

In practice, as we pointed out in § 1.3, the controller also supervises the overhead lines and looks after in particular the operation of all the line switches and sectionalizing switches. He has to know all the time the distribution of current in the overhead line and to be able to do so he has a plan of the sections. This plan is not to scale : it is a diagram indicating the sectionalizing, the points of feed, the lines electrified, etc., of the whole of the system which he has to supervise and for which he is responsible. The plan is a basic document of great importance, to which the controller has to refer constantly.

The classic conception of a post consists in materialising the sectionalizing plan by bars of colour stuck or rivetted to the diagram. There are three drawbacks to this type :

(1) difficulty of getting in line vertically the part panels of the signalling diagram and of the operating chart with the corresponding sidings of the stations on the other hand;

(2) difficulty and sometimes impossibility of showing all the secondary lines electrified, in particular those of the fans in the marshalling yards and in the shunting yards;

(3) great difficulty in modifying the sectionalizing diagram in view of its representation by the bars and the great cost of doing so.

To sum up, the controller finds himself near the centre of a large semi-circular diagram, the reading from a distance being difficult. When carrying out intended operations or suppressing non-compatible signals, he has to leave his desk each time and sometimes move some appreciable distance.

1.6. **Originality of the cabin built at Namur.**

Figure 2 reproduces part of the system to be remote controlled from the centre of Namur, with the respective distances from Namur to the various posts served.

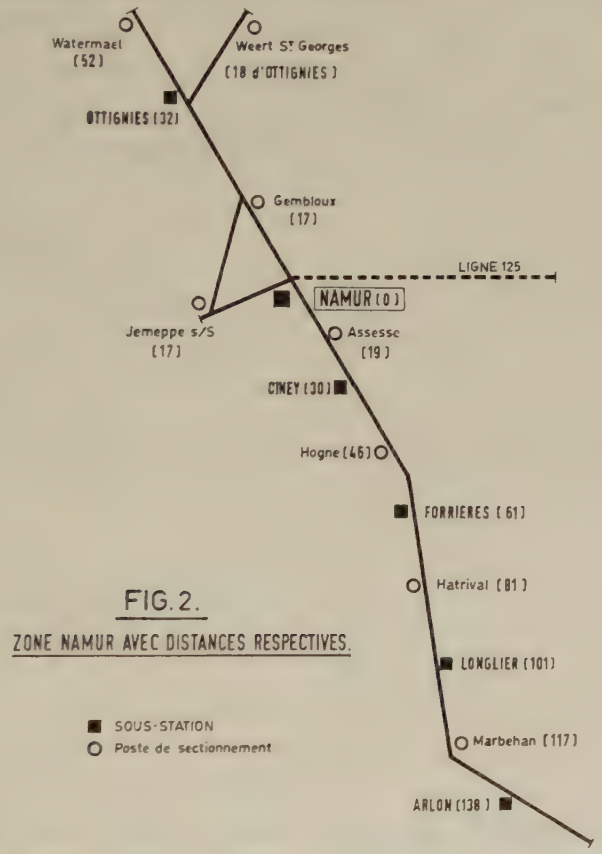


FIG. 2.

ZONE NAMUR AVEC DISTANCES RESPECTIVES.

Fig. 2. — Namur district with respective distances.

N. B. — Sous-station = substations. — Poste de sectionnement = sectionalizing post.

It should be noted that the telephone circuit serves Weert-Saint-Georges via Watermael (with return by Ottignies) so as not to have to install an aerial at Ottignies. Due to this the real distance from Weert-Saint-Georges to Namur is 90 km.

On this figure, we have shown by a broken line the Namur-Liège section, which will be electrified in a few years' time. As a part of the installations of this line will be subject to Namur, the S.N.C.B. has taken this into account in the installation studied in the present report.

TABLE 1. — **Remote operated and remote signalled equipment.**

	Subordinate posts	Remote operated				Remote signalled								
		A	SA+ S'A	G	U	Reg	TS	Cr	Ca	GB	=	~	48V	Loc
Substations	Ottignies	2		3	8	1	1	1	1	1	1	1	1	1
	Namur	2		4	8	1	1	1	1	1	1	1	1	1
	Ciney	2		3	5		1	1	1	1	1	1	1	1
	Forrières	2	1	3	5		1	1	1	1	1	1	1	1
	Longlier	2	2	3	5		1	1	1	1	1	1	1	1
	Arlon	2		3	5		1	1	1	1	1	1	1	1
Sectionalizing posts	W. St. Georges				2						1	1	1	1
	Watermael				2						1	1	1	1
	Jemeppe sur/Sambre				4						1	1	1	1
	Gembloux				6						1	1	1	1
	Assesse				4						1	1	1	1
	Hogne				4						1	1	1	1
	Hatrival				4						1	1	1	1
	Marbehan				4						1	1	1	1

Reference

A = arrival.
SA + S'A = pneumatic sectioners of the input supply and earthing.
G = power set.
U = feeder breaker.
Reg = voltage regulating installation.
TS = installation comprising 2 transformers for the auxiliary services.
Cr = installation of 2 compressors.
Ca = installation of 2 sets of ducts.
GB = installation to load the battery.
= = lack of 110 V D.C.
~ = lack of alternating voltage.
48 V = lack of 48 V D.C. voltage.
Loc = connection in the buildings.

At the present state of things, we note that the Namur remote controlled post has to be arranged to cover :

— 6 substations;

— 5 complete sectionalizing posts;

— 3 partial sectionalizing posts (limits of two districts of remote control).

In all, this represents in particular :

— 12 incoming high tension feeders;

— 19 3 000 kVA, transformer-rectifier groups;

— 66 3 kV feeders including 1 by-pass breaker in each substation.

Table I reproduces the list of all the apparatus to be remote controlled on the one hand, and to have distant signal operation on the other.

The S.N.C.B. has taken care to avoid the restrictions suffered from in the classic posts by directing its efforts to a quite different solution.

The illuminated diagram, made to a reduced scale, is built up of part panels arranged to suit the plan of the sectionalizing.

The controller also has at his disposal a *complete* plan of the sectionalizing with, in line with the stations concerned, the signalling of the corresponding remote controlled posts. This solution cannot, however, be carried out for important posts. Actually :

(1) the vertical correspondence does not always exist;

(2) the sectionalizing plan is sometimes interrupted with arrows directed towards quite other points which does not make the reading any easier;

(3) the sidings of the marshalling fan of sidings are only sketched in.

When going more deeply into the plan, the S.N.C.B. decided to bring together at the desk all the operating controls and only to let the signalling remain on the diagram.

As regards operating from the desk, it was desirable to adopt a solution requiring little space, so that the desk can retain its usual size.

Based on what has been achieved in the signalling posts of the « all relay » type, the S.N.C.B. decided to effect the operation by displacing two keys : one, the *selecting* for choosing the post affected, the other the *operating* for choosing both the switch to operate and the kind of manoeuvre to carry out (switch in or cut out). As a result, the operating equipment is reduced to a first panel with as many keys as there are posts to be operated and to a second panel with the keys of the large substations on the one hand, and of the most important sectionalizing posts on the other. This solution was possible because of the great standardisation adopted by the S.N.C.B. in the substations and sectionalizing posts (the general case in electric traction of the main line railways).

The two panels with keys, have been readily incorporated in the standard « dispatching » type desk which the S.N.C.B. has adopted for the controller.

As regards the signalling diagram, it has been built with miniature type lamps and the sectionalizing plan has come within the dimensions of an ordinary folder. As a result, the controller can work seated all the time, which enables him to devote his attention simultaneous-

ly — as it is desirable — to his principal occupation, namely to follow the automatic cutouts or to carry out operations whilst watching the part of the sectionalizing diagram affected by the incident at the moment, to keep up to date at the same time his register of telegrams, releases, etc., and to use the telephone.

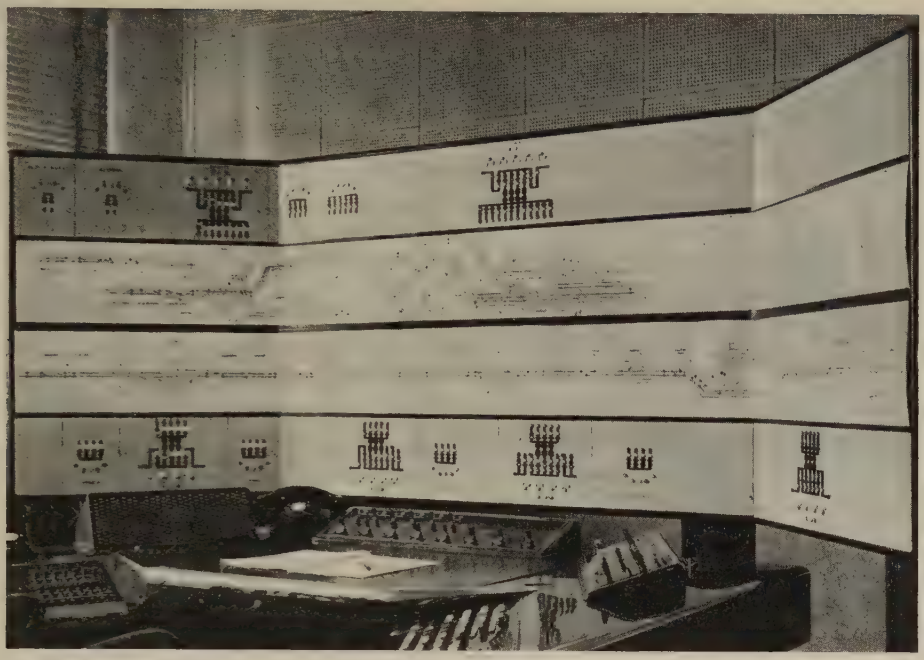
Without going into greater detail at present, it will be appreciated that the premises will be very reduced in size and will ressemble a dispatcher's office. The equipment is no longer secured to the back of the diagram but arranged methodically in an adjacent relay room.

At Namur, however, the premises remain fairly large because extensions have been provided for in the future, though when is not known.

We can summarize what has been written above by saying that in his new post, the controller need never leave his desk to carry out remote operated manoeuvres and can read very easily his sectionalizing diagram complete as it is.

Moreovoer, all the signalling of a controlled post is grouped to the right of the corresponding part of the sectionalizing plan. This facilitates the work of the controller and speeds up his means of action in case of incident, damage or cutting off current for repairs.

Moving an operating lever.
Below : telephone key board.



Operating desk of the general diagram on which are grouped the signallings and the sectionalizing plan.

§ 2. PRACTICAL REALISATION.

2.1. The state of the installation at the moment it is brought into service.

From Table I, we have drawn up Table 2, which is complete and includes in detail all the remote operation controls, on the one hand, and the signalling, on the other. The figures shown later between brackets are repeated in the table and indicate the number of operations (for example : switching in + cutting out : 1 + 1 = 2) and the number of remote signalling movements to be made.

2.1.1. Remote operations.

(*a*) Switch in or cut out 1 incoming switch A (2);

(*b*) Switch in or cut out 1 incoming pneumatic section switch or 1 pneumatic earthing switch of an incoming line SA + S'A (2 + 2).

At Forrières and Longlier, the section switches are provided for de-icing the high tension line through the Ardennes; they are operated when requested by the supplier of the current who then puts his lines into short-circuit under low voltage.

(*c*) Switch in or cut out 1 power transformer-rectifier group G (2);

(*d*) Switch in or cut out 1 feeder or by-pass of a substation U (2) [1];

---

[1] Idem for the breakers 5 and 6 of the Jemeppe sectionalizing post.

TABLE 2. — **Detailed programme.**

Subordinate posts		Remote operated					Remote signalling (on the signalling diagram)														
		A (2)	SA+S'A (2)+(2)	G (2)	U (2)	U (3)	A (7)	SA+S'A (8)	G (7)	U (6)	U (7)	U (4)	Re (5)	Ts (4)	Cr (4)	Ca (5)	GB (5)	= (1)	~ (1)	48V (1)	Loc (1)
Substations	Ottignies	2		3	8		2		3	8			1	1	1	1	1	1	1	1	1
	Namur	2		4	8		2		4	8			1	1	1	1	1	1	1	1	1
	Ciney	2		3	5		2		3	5				1	1	1	1	1	1	1	1
	Forrières	2	1	3	5		2	1	3	5				1	1	1	1	1	1	1	1
	Longlier	2	2	3	5		2	2	3	5				1	1	1	1	1	1	1	1
	Arlon	2		3	5		2		3	5				1	1	1	1	1	1	1	1
Sectionalizing posts	W. St. Georges					2					2							1	1	1	1
	Watermael					2					2							1	1	1	1
	Jemeppe s/S.				2	2					2	2						1	1	1	1
	Gembloux					6					6							1	1	1	1
	Assesse					4					4							1	1	1	1
	Hogne					4					4							1	1	1	1
	Hatrival					4					4							1	1	1	1
	Marbehan					4					4							1	1	1	1
Part totals		24	12	38	76	84	84	24	133	216	196	8	10	24	24	30	30	14	14	14	14
General totals						234															835

(*e*) Switch in on the overhead line or bar, and switch out 1 breaker of sectionalizing post U (3) ([2]).

2.1.2. **Remote operated signalling.**

Preliminary remarks.

By incompatibility or discordance in the switched in or out position of a breaker, we understand that the breaker is in or out whilst the corresponding remote controlled equipment at the controller's post is not in agreement with this position. In other words : in the case of automatic functioning, or of local control starting from the subordinate post, the colour of the blinking light at the controller's post corresponds to the new position of the apparatus; in the case of remote control not followed by the corresponding manoeuvre of the apparatus, the colour of the blinking light corresponds to the primitive position of the apparatus.

(*a*) Signalling of the incoming lines : fixed green light or fixed red light for the switched in or cut out concordant positions; same blinking lights for the case of discordance. A blockage on an incoming line shows itself by a violet light (to note that this blockage acts on the other incoming line as well). A drop in voltage on an incoming line shows itself by a fixed yellow light, whereas a cut out of the metering protection breaker, or the absence of 110 V D.C. of the incoming line cutouts show themselves by the blinking of this same yellow light.

In all, there are $2 + 2 + 1 + 2 = 7$ A signallings (7).

(*b*) Signalling of the pneumatic sectionners of the incoming lines SA and the earthing switches of the incoming lines S'A : fixed green light or fixed red light for the concordant cut-out or switched in positions, same blinking lights for the cases of incompatibility.

In all $2 + 2 = 4$, that is for S + S' (8).

(*c*) Signalling of the power transformer/rectifier groups :

fixed green light in the case of concordance of the two breakers (H.T. and cathode) switched out;

fixed red light in case of concordance of the two switched in breakers;

blinking green light in case of discordance between the two cut out breakers;

blinking red light in case of discordance between the two switched in breakers;

blinking green *and* red lights in case of switching out or not switched in of one of the two breakers;

white light in the event of arcing on the return;

violet light in case of the blockage of the groups.

([2]) At the sectionalizing post, there are two possible methods of switching in :

1) *on the overhead line :* in the event of cutting out the breaker re-sets itself automatically as soon as the voltage in the section concerned attains 3 kV; there is then a supply to the corresponding breaker in the neighbouring substation;

2) *on the bar :* in case of cut-out there is jamming. The switching in does not require the voltage of 3 kV on the section affected. It is to be noted that the normal switching in is that to the overhead line. For particular switching in reasons at the Jemeppe sectionalizing post, two breakers have been provided — numbers 5 and 6 — with direct switching in as in the substations : for these two breakers there is only one switch in.

In all : 4 + 1 + 1 + 1 = 7 G signallings (7).

(*d*) Signalling of the feeder breakers of the substations (the by-pass breakers are also arranged in this category) :

fixed green light or fixed red light for the concording contact or switched in positions, same lights blinking for the cases of discordance;

blinking red *and* green lights in case of cut out with blockage;

a special red lamp (1 per breaker) lights up when the section switch replaced by the by-pass breaker is closed (this lamp indicates that the two sectionalizing switches are closed when it is a question of the by-pass itself).

In all : 4 + 1 + 1 = 6 U signallings (6).

(*e*) Signalling of the feeder breakers of the sectionalizing posts :

green light, fixed or blinking, for concordant or discordant switching out positions;

red light, fixed or blinking, for concordant or discordant switched in positions, for switching in at the overhead line or on the bar;

blinking red and green light in the case of cut out on the bar with blockage.

In all : 2 + 2 + 2 + 1 = 7 U signallings (7).

For the breakers Nos. 5 and 6 at Jemeppe, there is no switching in to the bar nor of blockage.

In all : 2 + 2 = 4 U signallings (4).

* * *

Now let us review the signalling of the auxiliary services.

(*f*) Signalling of the substation voltage regulators : at the Ottignies and Namur substations, the high tension is supplied with guaranteed voltages between ± 10%.

In this case the S.N.C.B. installs a regulation under load of the voltage of 3 kV. The automatic control of the regulating apparatus is known as « regulorel ». This equipment is duplicated. The signalling is as follows : fixed white lamp I or II indicating that the « regulorel » I or II is in use. In the case of automatic commutation, the lamp becomes blinking for the one that was in service before the commutation, whereas the light comes on fixed white for the other « regulorel » which comes into use. Consequently, for each white light we have the fixed light (concordance) or the blinking light (discordance).

In addition, 1 fixed yellow light indicates a fault.

In all : 2 + 2 + 1 = 5 Reg. signallings (5).

(*g*) Signalling of the transformers for auxiliary services in the substations.

In each substation, there are 2 similar transformers with automatic switching. The signalling follows the same processus as in (*f*) above.

In addition, one fixed yellow lamp indicates a lack of alternating voltage.

In all : 4 + 1 = 5 signallings, which we note (4 + 1) as we keep apart the lack of alternating voltage by analogy with the sectionalizing posts Ts (4) ~ (1).

(*h*) Signalling of the air compressors in the substations.

In the case of the pneumatic breakers,

2 compressors are in each substation with automatic switching. The signalling is identical with that described under (*f*) above. Moreover, the yellow lamp is an after thought.

Therefore, in all : 4 Cr signallings (4).

(*i*) Signalling of the compressed air mains in the substations.

Two sets of mains are provided in each substation without automatic switching. The signalling follows the same processus as in (*f*) above. A fixed yellow lamp indicates a lack of pressure.

In all : 4 + 1 = 5 CA signallings (5).

(*j*) Signalling of the 110 V D.C. charging sets in the substations.

There are two such sets in each substation with automatic switching. The signalling follows the same processus as under (*f*) above.

The yellow light can be fixed (lack of D.C. voltage) or blinking (battery switch cut out).

In all : 2 + 2 + 2 = 6 signallings, which we will note as (5 + 1) as we keep separate the lack of 110 V D.C. by analogy with the sectionalizing posts GB (5) = (1).

(*k*) Signalling of the 110 V D.C. charging sets in the sectionalizing posts.

There is only the blinking yellow light indicating the cutting out of the battery switch, which may result in a lack of D.C. voltage. We have inserted this signalling in the column « lack of 110 V D.C. » = (1).

(*l*) Signalling of the alternating voltage at the sectionalizing posts.

A fixed yellow lamp indicates a drop in A.C. voltage ~ (1).

(*m*) Signalling of the 48 V D.C. charging sets (all posts).

A fixed yellow light indicates a drop in the 48 V (1).

(*n*) Signalling of the local operation (all posts).

A fixed red lamp indicates that the operation of a subordinate post has been taken over locally LOC (1).

(*o*) Taking sections out of service.

A section is taken out of service by extinguishing all the lights in it. In this way, the attention of the controller is called to the fact of work being in hand on the equipment of this section. He then has no longer neither the remote control nor the signalling; he retains the control and operation of all the other equipment of the post affected. By sections taken out of service, we understand : the incoming feeders, the power sets, the feeders, the « regulorel » equipments, the TS (2 separate taking out of service for the 2 Ts), the compressors + the mains and the battery charging sets.

In all, this gives : 12 (A) + 19 (G) + 38 (U substations) + 29 (U sectionalizing posts) + 2 (Re) + 12 (Ts) + 6 (CR + CA) + 6 (GB) = 123 signallings of taking out of service.

These are not entered on Table 2.

2.1.3. **Various other signallings.**

In addition to all the signallings referred to above and which concern exclusively the signalling table, there are

further indications installed at the operating desk. These are :

(*a*) a fixed white lamp per each selecting lever which indicates a discordance has occurred with the apparatus of the post corresponding to this key (case of a change of position not ordered). There are 14 posts so arranged and therefore 14 white lamps.

(*b*) a yellow lamp per selector lever which indicates :

— by a fixed light, a broken wire between the appliance remote controlled and the remote controlled apparatus in the subordinate post;

— by a blinking light, which may indicate that a signalling request is being dealt with or that after any signalling

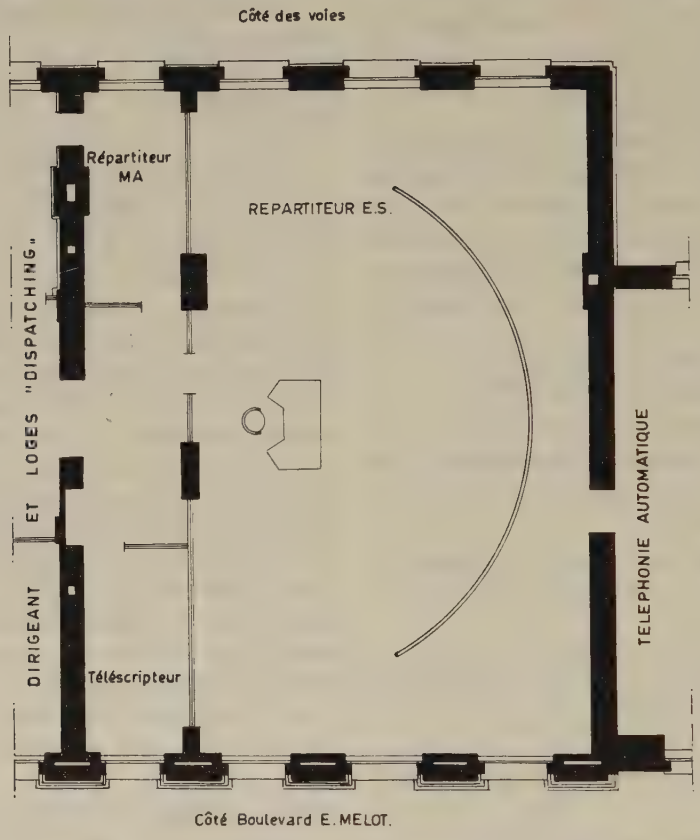


Fig. 3. — Former arrangement of the buildings.

Explanation of the French wording :

Côté des voies = side facing railway lines. — Répartiteur = controller. — Dirigeant et loge « dispatching » = manager and dispatching rooms. — Téléscripteur = Telewriter. — Côté boulevard E. Melot = side facing boulevard E. Melot.— Téléphone automatique = automatic telephone.

(order, cut out not ordered or request for signalling) the subordinate post does not reply.

In all : 14 yellow lamps with 2 meanings, that is 28 indications.

(*c*) per line, 1 red lamp FU which indicates that a fuse in the cupboards of the control post corresponding to this line has melted.

In all : 4 signallings.

(*d*) per line : 1 red lamp SL which indicates by a fixed light either a break in the line or lack of synchronisation through receiving a bad signalling; in this case, a request for signalling of the line restores the normal situation.

In all : 8 signallings.

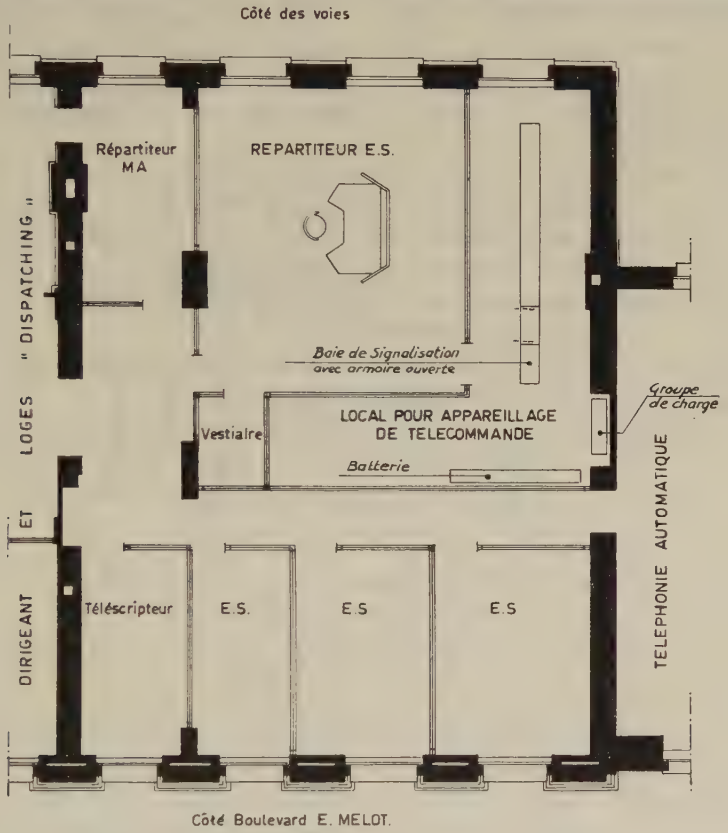


Fig. 4. — New arrangement of the buildings.

Explanation of the French wording :

Côté des voies = Side facing railway lines. — Dirigeant et loges « dispatching = manager and dispatching room. — Répartiteur MA = MA controller. — Téléscripteur = telewriter. — Répartiteur ES = ES controller. — Local pour appareillage de télécommande = room for remote operation equipment. — Batterie = battery. — Groupe de charge = charging set. — Téléphonie automatique = automatic telephone. — Côté boulevard E. Melot = side facing boulevard E. Melot. — Baie de signalisation avec... = signalling desk with cupboard behind.

* * *

To conclude, we arrive at the following totals :

Possible number of remote operations : 234.

Number of remote signallings : 835 + 123 = 958 at the diagram.

Number of remote signallings at the desk : 54.

Total : 1 012.

Actually, this line will be electrified at some more or less late date.

Other extensions are also possible.

2.3. **Layout of the buildings.**

When starting the preliminary study of the remote operation of Namur, the buildings were arranged as shown in figure 3. The diagram of signalling and control was the same as in other Belgian posts and measured 15 m in length by 2.5 m in height. The place reserved for the controller was 14 m long and 7.90 m wide. Just as in the old layouts, the equipment was arranged behind the diagram. In addition, this room was surrounded by the dispatching rooms and also by those of the telephone centre. Every time, the telephone mechanics had to attend to the telephones in the dispatcher's office and to maintain them, they had to go through the E.S. Controller's room.

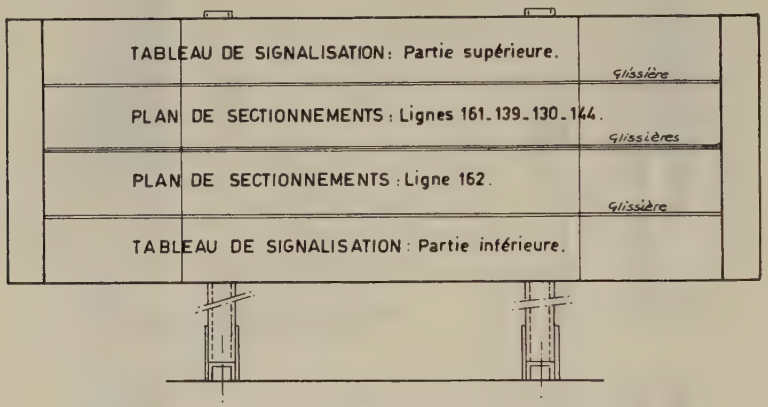


Fig. 5. — General arrangement of the signalling diagram.
Signalling diagram : upper part
Sectionalizing plan : lines 161, 139, 130, 144
Sectionalizing plan : line 162
Signalling diagram : lower part

The 958 signallings are shown on the panels, the total area of which is 1.25 m² including the make up panels (1).

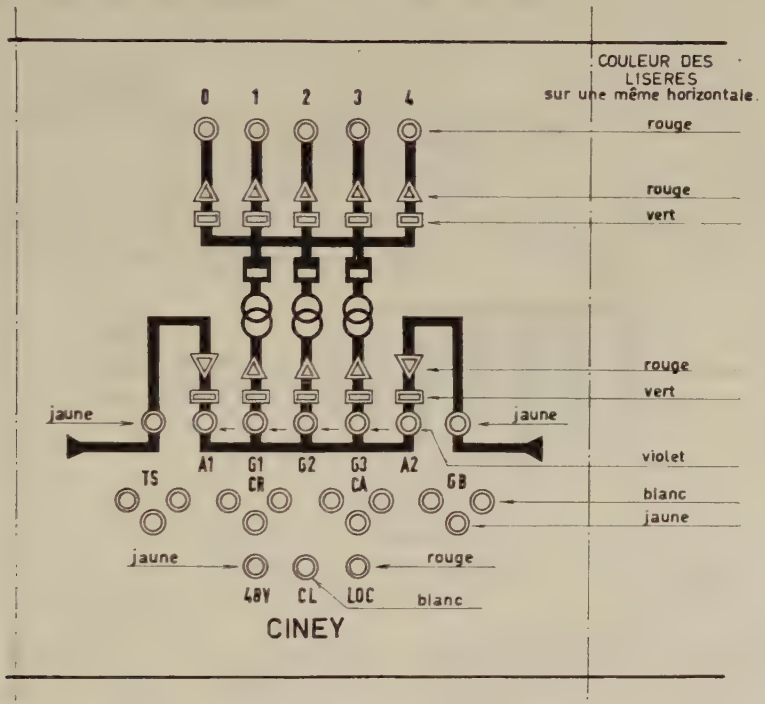
2.2. **Extensions to be expected.**

The installation has been thought out in such a way as to allow the remote operation of the posts on the Namur-Liège line to be installed when needed.

(1) The equivalent central area of the diagram is occupied by the diagrammatic sectionalizing plan.

Figure 4 shows the new layout made possible by the new system of control. As can be seen, the new dimensions are 7.90 m and 8.25 m (instead of 14 m). The result was a great saving of space, which has been utilised to give a wide access corridor to the telephonists and to provide three offices. In the new dimensions given, there is a large room for the equipment with a direct access door from the controller's room.

This room also has been made amply large and will allow of quite important extensions (over 75%). Beside the cabinets containing the equipment, there is room for an alcaline battery of 48 V 150 Ah and a double group of rectifiers to charge it. Finally, and always within the dimensions given above, there is a cloakroom measuring 1.5 m by 2 m.



Section of the SIGNALLING DIAGRAM. — LOWER PART (fig. 5).

Fig. 6. — Drawing of the « Ciney » panel.

N. B. — Couleur des glissières sur... =colour of the borders on one particular horizontal line. — Rouge = red. — Vert = green. — Violet = violet. — Blanc = white. — Jaune = yellow.

The following advantages are at once appreciated :

(1) a notable gain of place which means a substantial saving in building it;

(2) a very pleasant working atmosphere resulting from the functional character of the arrangements used.

2.4. **The design of the illuminated diagram.**

Figure 5 shows the whole layout of the signalling diagram composed of 4 horizontal bands. The top band gives information relating to the position of the appliances in the subordinate posts of the lines 161, 139, 130 and 144.

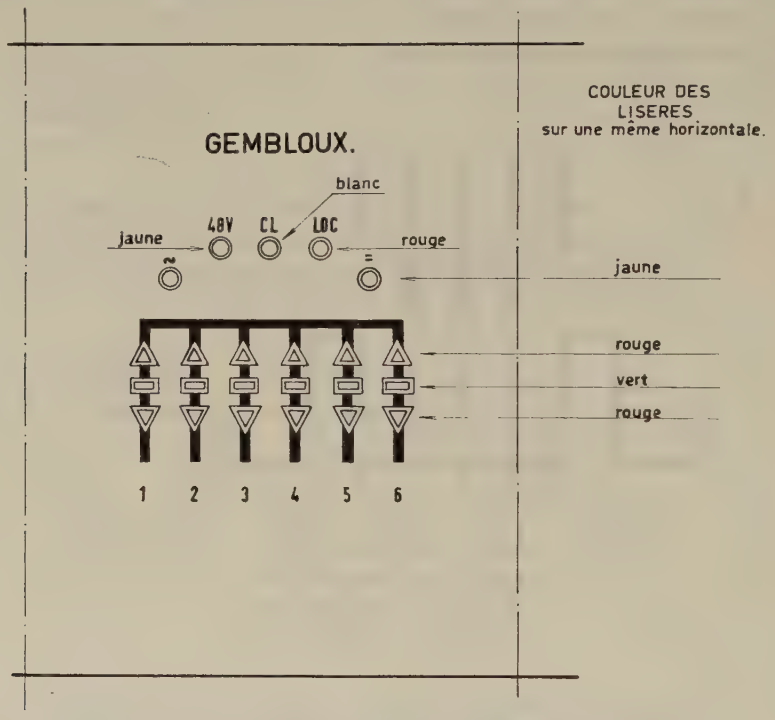
The bottom band gives the same information for line 162. The middle bands are made up of the corresponding sectionalizing plans.

The respective dimensions of the different elements has been selected to take into account in particular what follows :

(1) the sectionalizing plan placed about 1 m from the man in charge is perfectly legible in its smallest details, even as regards the numbering of the tracks in the fan of sidings;

(2) the signalling of each subordinate post is shown to the right of the corresponding lines in the station shown in the sectionalizing plan;

(3) the signalling symbols (form and colour, size of lights, etc.) enable them to



Section of the SIGNALLING DIAGRAM : UPPER PART (fig. 5).

Fig. 7. — Drawing of the Gembloux panel.

N. B. — Couleur des lisières sur une... = colour of the borders on one particular horizontal line. — Jaune = yellow. — Rouge = red. — Vert = green.

be read easily, to be interpreted quickly and without any possible doubt.

Figure 6 shows the layout of a substation luminous diagram. The black lines are reproduced by a narrow bar in black plastic stuck on the diagram and give a single line image of the scheme. The luminous symbols are about 1 m from the operator and give a solid angle of reading more than adequate. The signification of the lights has been given in chapter 2.1 above.

We can say too that the signalling of a sectionalizing post is definitely less important. Figure 7 gives an example of a sectionalizing post on the Namur-Brussels line.

2.5. The desk and its arrangements as carried out.

Figure 8 shows the desk. Relatively to the normal desks provided by the S.N.C.B. the following modifications have been made :

(1) the 2 panels with keys (for selecting and for operating) have been built into the desk. These panels could have been brought nearer to the operator but this was not done so as to leave a large area free for writing. However to facilitate access to these panels, they are inclined at an angle (about 25% slope). Figure 9 shows the layout of the keys in the operating cabinet;

(2) the usual loud speaker case has been replaced by one very reduced in height to let the bottom of the signalling panel to be read, this panel being placed on the edge of the desk. Nevertheless in this new case not one but two loud speakers, small and eliptical in size and carefully selected, have been fitted. One of these permanently allows the operator to listen in on the regulation

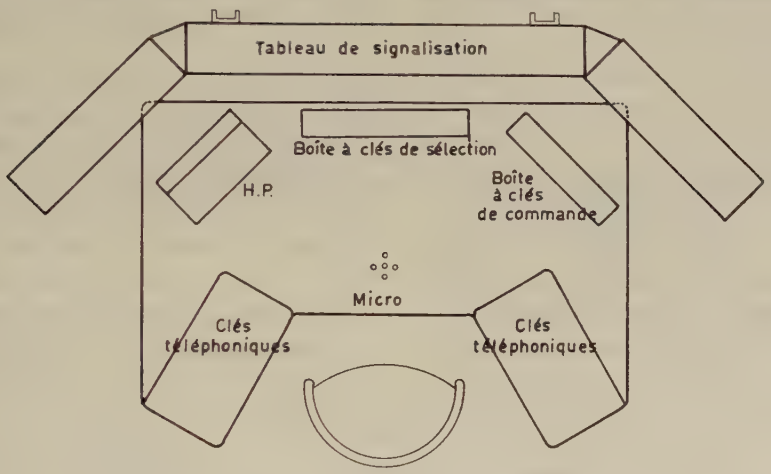


Fig. 8. — Controller's desk.

N. B. — Tableau de signalisation = signalling diagram. — Boîte à clés de sélection = case of selection keys. — Boîte à clés de commande = case of operating keys. — Clés téléphoniques = telephone keys.

circuit, and the second in all the others (automatic telephone circuits, the S.O.S. circuits, direct lines with the dispatcher, etc.).

In this way, the use of the desk stand telephone set is no longer essential. The desk so modified carries all the buttons, all the keys and the lamps required for operating the post.

— 36 signalling lamps of various types for the remote operation (tests, lines, etc., see 2.1.3);

— a large number of spare keys in reserve.

By the judicious layout of these appliances and by using various colours, the desk has a well ordered appearance and never lends itself to any confusion.

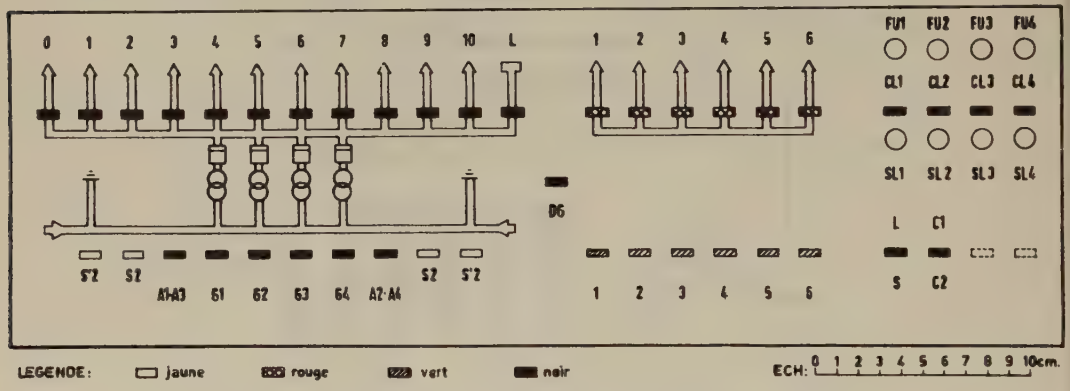

0 1 2 3 4 5 6 7 8 9 10 L
1 2 3 4 5 6
FU1 FU2 FU3 FU4
CL1 CL2 CL3 CL4
SL1 SL2 SL3 SL4
L C1
S C2
DG
S'2 S2 A1-A3 61 62 63 64 A2-A4 S2 S'2
1 2 3 4 5 6
LEGENDE: jaune rouge vert noir
ECH: 0 1 2 3 4 5 6 7 8 9 10cm.

Fig. 9. — Arrangement of the keys in the operating cabinet.
N. B. — Jaune = yellow. — Rouge = red. — Vert = green. — Noir = black.

At the desk there are :

— 1 case with two loud speakers and 2 witness lamps;

— 1 microphone built into the table;

— 1 desk stand telephone set in reserve;

— 1 universal impulse key as stand by and 2 witness lamps;

— 19 telephone keys, almost all two position;

— 97 call buttons of the special regulation circuit;

— 41 operating and control keys of the remote control (almost all two position);

— 14 remote operation selection keys, all two position;

We may add that the supports of the desk provide large storage space in which the documents in current use by the controller can be stored methodically.

2.6. **Layout of the relay and auxiliary service cupboards.**

(*a*) The relay room is close to the controller. The diagram and the cabinets are connected by nearly 800 wires (1).

(1) These wires are divided into :
remote control : diagram 578; desk 130;
telephone : 160 + 3 coaxial cables.
All these wires pass through a duct resting on the ground and covered by the same flooring as the controllers room.

Figure 4 shows the general layout of the cabinets and shows broadly the opening the builder proposed for the doors. In this way, the doors (front) open completely without trespassing on the passage reserved in front of the cabinets.

The back panels are detachable.

(*b*) In this same relay room, there are also :

— the transformer/rectifier charging sets which can simultaneously charge a 48 V battery and feed the remote operation (2 sets), the full battery charge and 1 automatic switching in the battery in case of shortage of alternating voltage;

— the alcaline battery.

This equipment has been designed on a large scale to meet any possible probable extensions.

2.7. **Lighting problems.**

The lighting of the control premises includes :

(*a*) a general lighting by 4 ceiling fittings set in the ceiling with 32 W « circleline » lamps;

(*b*) a 2×40 W wall fitting on the wall opposite the windows so as to balance the daylight coming through the windows in case of dull weather.

(*c*) a 48 V spot light for emergency lighting of the desk;

(*d*) two special projectors (theatrical type with profiled screens) to illuminate the central part of the diagram reserved for the sectionalizing plans. The diagrams alone are lighted up, the signalling panels only receiving a little diffused light. In this way, the plans are perfectly readable and the luminous panels of the diagram are not so illuminated as to render it uncomfortable to read the luminous symbols since the diagram has its lights on permanently. The intensity of these 2 projectors is adjustable between 0 and 100% by 1 suitable potentiometer, whilst in its turn the intensity of the lights of the illuminated diagram is adjustable by means of other potentiometers.

— The ability to illuminate the sectionalizing plans without lighting up the luminous panels of the diagram has great merits.

The whole installation works to the entire satisfaction of the staff who have not complained of fatigue.

2.8. **Processus of operation.**

In the old system, the fact of going from the desk to the diagram to select on it the panel concerned (post X), to select the lever affected and in the desired position, excluded any possibility of confusion or error. In the new system, the operator has at his disposal keys, operated at arm's length from his seat, which make it easy to carry out an operational order. Is there any risk of errors, confusion, or orders sent out too easily? These objections have been met by carrying the order out in several stages. Let us suppose the controller wishes to switch in the breaker U3 of the Ciney substation. Before the manoeuvre, the U3 of Ciney is controlled at the diagram in the cut out position, that is to say by a fixed green light.

First stage.

The controller turns towards himself (lower position) the Ciney selection key on the selection casing which lies in front of him on the desk. At this moment on the signalling diagram the light of all the lighted lamps of the Ciney substation dims appreciably. In this way, the controller has checked that he can properly carry out an operation at the Ciney substation.

Second stage.

Whilst keeping with his left hand the Ciney key reversed (as said above), the controller with his right hand reverses the U3 key of the substation in the upper position « switched in » (operational panel to the right of the desk). At this instant, in the middle of the dimmed Ciney lamps, the U3 lamp lights up with full luminosity in correspondence with the position desired (here « switched on », and so fixed red light).

Third stage.

Having checked in this way that he has properly prepared the way for a manoeuvre at Ciney and that it has properly « switched in U3 », he reverses the selectioning key to the upper position (naturally whilst maintaining the U3 key reversed). At this moment the order for remote operation goes out and the keys can be released. The fixed red light of Ciney U3 goes out (control over) and the green becomes blinking because of the discordance between the remote operational apparatus and the position of the breaker (1). All the Ciney lamps are now at their normal luminosity. At the same time 1 CL lamp is blinking on the Ciney panel during the whole duration of the transmission of the order. At the end of the manoeuvre, the CL lamp goes out and the blinking green is replaced by the fixed red of U3 if this latter switches in. If the order is not followed by switching in, the blinking green persists. The blinking can then be cut out by the lower position of the Ciney selection key.

It is not possible therefore to make a wrong manoeuvre in spite of easy access to and the small distance apart of the operational keys. This fact has been confirmed by experience.

* * *

§ 3. THE SYSTEM ADOPTED.

3.1. Particular features of the specifications.

We will only refer again briefly to the fundamental modification consisting of the replacement of the operational diagram and signalling with the lights extinguished by an operating desk and signalling diagram with lights illuminated.

Let us repeat once again that the white light of the lever (old system) has been replaced by a red light in the form of a triangle pointed in the direction of the current and a green light in the form of a bar vertical to the passage of the current for the remote operated apparatus and by white lights surrounded by coloured edges for the remote signalled apparatus.

For the signalling we have added :

— signalling of the return arc in the power sets;

(1) See 2.1.2. Preliminary remarks.

— signalling of the taking out of service of the part of any apparatus : as it is a question of a diagram with the lights on, we have shown this on the diagram by extinguishing the lamps of the part concerned;

— a lamp « broken wire » per post automatically indicating that at this post there is break in the set of wires between 1 apparatus and the remote operational cabinet (example of bad transmission of polarity by the apparatus by fusion of the fuse in this circuit).

As regards the transmission of remote control of operation, the 2 wire system has been specified everywhere. The transistor technique being very new at the time when the specification was drawn up, the method using direct impulses with relay was the only one retained. There is no doubt that for 1 post of remote operation at the present time an electronic transmission could be accepted. This moreover would not raise any especially difficult problems. Does not one speak of sending more than 200 different signals in one second? The time of transmission on the line will no longer count !

In the Namur system, we have been able to reduce the total time of transmission to about 8 seconds, an important gain relatively to that previously attained on the S.N.C.B. To this saving, we have to add on the movements of the controller on duty between the desk and the diagram, which sometimes were considerable.

We also added at Namur the means for cutting out all remote operated equipment of a given post by a single general switching out lever which to be thrown over had to be raised to begin with to call the controller's attention to the seriousness of this manoeuvre. The high tension incoming lines, however, did not obey the general switching out so as to continue to supply alternating current to all the auxiliaries. The S.N.C.B. preferred this method : it is always possible to switch out individually these incoming lines if necessary.

Finally, the most striking innovation has been making the installation sectionally dismountable so that :

— all the relays except those of the « brains » can be removed individually;

— all the « brains » (1 per line);

— all the selectors;

— all the part panels of the signalling diagram can be taken down individually;

The result is great facility in handling and great speed in replacement for repairs or if damaged.

§ 4. CONCLUSIONS.

The remote operational post at Namur shows with regard to its predecessors the following advantages :

(1) the dimensions of the building are much smaller; the working conditions are pleasant;

(2) saving in first cost and upkeep corresponding to the reduction in size;

(3) the signalling diagram has in all cases exactly in line with the luminous panels of each post under control the complete diagram of the corresponding station lines. This results in rapidity of reaction by the controller in the event of damage, or loss of current, etc.;

(4) the sectionalizing plan is complete to its smallest details (the numbers of the sidings in the fan for example) and perfectly readable. Particular care has been given to the lighting;

(5) the operation, from the desk, obviates long movements by the controller and enables him to make simultaneously a manoeuvre, to speak to a member of the staff out on the line, to note alterations occurring, etc.;

(6) the mobility of the system is great should modifications be called for :

— the diagram of the sectionalizing is on paper (of specially carefully selected shades);

— the luminous panels are connected by multiple plugs with a good reserve of cables;

— the selection keys can be added to to a considerable extent.

It will therefore be possible to meet any future extension of the electrification in the zone dealt with.

* * *

The Namur installation opens the way to a new type of centralised operating post of the electric traction substations and the first in operation seems to assure its success.

[656 .25 (73)]

High speed data transmission,

by John L. Wheeler.

(*Railway Signaling and Communications*, April 1960.)

Electronic data processing systems have received rapid acceptance by many railroads. Because of the current interest in E.D.P., Railway Signaling and Communications feels that this paper, presented at an Institute of Radio Engineers symposium, contains much useful information for the railroad communications engineer. It is with the permission of the I.R.E. that we publish this abstract.

This paper discusses some of the problems associated with the transmission of digital information at high rates over telephone facilities. It presents some methods of overcoming these problems, and describes the performance of a system tested over regular commercial telephone circuits.

Suppose that there are two electronic computers located some distance apart, each capable of producing and using reels of magnetic tape containing large amounts of data. The requirement is that a complete magnetic tape message be transmitted rapidly and accurately from one machine to the other. A data transmitter

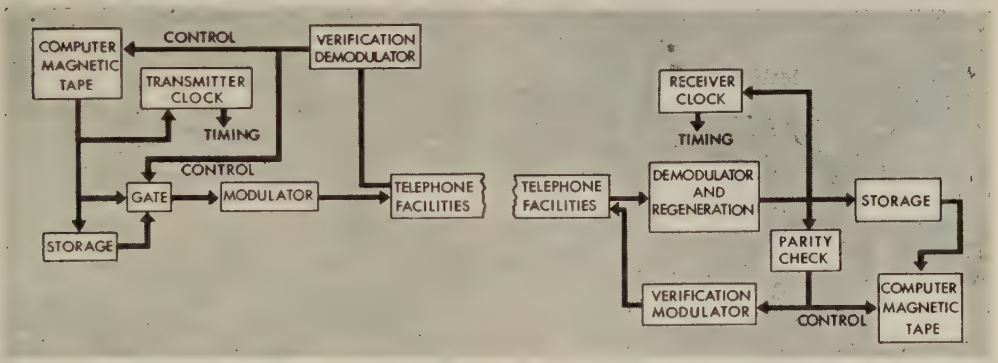


Figure 1: Transmitter (left). **Figure 2:** Receiver (right).

While it is possible to make available a modular line of components which can be put together to produce many varied data communication systems, the steps in the necessary design procedure can better be described by referring to a particular system. One system is typical of those required where large amounts of data must be transferred rapidly and economically.

which will meet the requirements at one end of the communication link is shown in figure 1.

The magnetic tape reproducer, which holds one reel of tape prepared by the computer, is connected, through a gate, to the modulator unit. The reproducer is operated so that it transmits data in blocks, or records, each containing many characters. The modulator converts the

data in some manner, and prepares it for transmission through the telephone facilities.

Transmit. — Then check.

At the start of transmission, the magnetic tape reproducer sends one block of data through the modulator and over the telephone facilities to the receiver at the other end. It then hesitates while the transmitter waits for a reply. The receiver checks the incoming data, and if no errors are discovered, sends back a verification response to the transmitter. This response is recovered by the verification demodulator.

It instructs the magnetic tape reproducer to send another block of data. This too is transmitted and verified by the receiver. All timing is accurately controlled by the transmitter clock.

In the event that an error is detected at the receiver, a different operation must take place. While the magnetic tape reproducer was sending information to the modulator, it was also connected to the input of a storage unit. After a block has been transmitted, the data contained in that block is also held in storage at the transmitter. If the verification response signal is not received by the transmitter, then the magnetic tape reproducer does not send the next block. Instead, the previous block is transmitted from the storage unit, through the modulator, and over the telephone facilities. The signal must be read out nondestructively from the storage unit, so that if a verification response is not received the second time, the transmitter will send the same block of information the third time. After a verification is received, the transmitter returns to the normal mode of operation, and the magnetic tape reproducer again supplies more data. A block diagram of the data receiver is shown in figure 2.

The signal coming in from the telephone facilities is demodulated and regenerated so that it again becomes accurately-timed binary information. It is entered immediately into the receiver storage unit. The timing of the incoming signal is used to synchronize the receiver clock, which provides pulses for all of the digital operations in the receiver.

At the same time, the regenerated binary information is sent to a parity checking unit which examines the signal using a weighted counting circuit, and compares the result with a transmitted parity check character. If no errors are detected, the verification modulator transmits a tone back to the transmitter which tells it to proceed with the next block. At the same time, the magnetic tape recorder is instructed to begin to record the previously transmitted block as it is taken from the receiver storage unit.

If the parity check unit detects the presence of an error in the received block, the verification modulator does not generate a response and the magnetic tape recorder does not record the block just received. Instead, it waits until the retransmitted block has been examined. Only those blocks which have no detectable errors will be recorded on the magnetic tape, which eventually is used by the computer located near the receiver terminal.

There are two basic design problems associated with the transmission of digital data over telephone facilities. One of these is impulse noise; the other is phase distortion. When toll circuits are involved, two other types of problem are also encountered. One of these is the frequency translation which results from the use of single sideband voice carrier channels, and the other is the sudden change in level produced by compandors used in the line.

Telephone line interference.

Most interference on a telephone line is not random noise. Instead it consists of intermittent bursts of short pulses, gene-

rally of high amplitude, which are induced in the line by weather conditions and man-made devices. Some of the interfering energy of these impulses may be removed through the use of a good automatic gain control circuit and peak clipping. Additional interfering energy may be removed by restricting the bandwidth of the frequency components allowed to enter the receiver.

Very bad cases of phase distortion, which may be caused either by intentional loading of the lines to improve the voice characteristics, or by sharp cut-off filters inserted in the circuit, may be improved by fixed phase equalization networks located in series with the line. While adjustable phase equalization may be used to adjust the line for each transmission, this is not desirable, because it requires highly skilled operators and precise measuring equipment. Another way of overcoming the problem of phase distortion is to reduce the bandwidth of the frequency components allowed to enter the receiver. If the received spectrum is made narrower, then the envelope distortion over the frequency range of the received signal will be greatly reduced.

Note that both of these problems, impulse noise and phase distortion, may be overcome to a great extent by narrowing the bandwidth necessary to transmit information at a given rate. Therefore, efforts should be concentrated on methods of preparing the signal for transmission, and of interpreting the received signal, which requires a narrower band of frequencies for successful transmission.

A digital modification circuit used in conjunction with the proper filters can be used to reduce the magnitude of the frequency components present in the binary signal at both upper and lower ends of the band. In order to understand the operation of this modifying circuit, it would be helpful to describe several steps in the development of the circuit.

First of all, let us consider the direct transmission of a normal binary code signal. The information to be transmitted consists of a series of ZEROS and ONES, as shown in figure 3.

The signal to be transmitted in this case is 001001110. The binary code signal is shown directly underneath the numerical information. Each ONE is represented by a positive voltage, and each

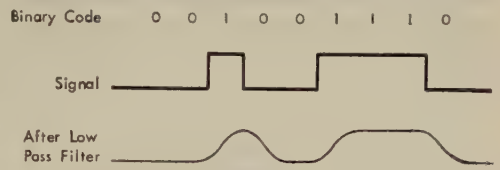


Figure 3.

ZERO by a negative voltage. A low frequency response is required in order to transmit this signal because there may be a long train of pulses of the same polarity. The cross-over sharpness of the binary code signal is provided by the presence of high frequency components. The bottom signal shows what happens to the binary code after it is passed through a low-pass filter which removes the higher frequency components. Transmission of this type of signal over telephone wires is generally unsatisfactory because both the amplitude response and the phase response must be flat over a broad range of frequencies. This is a difficult condition to obtain with average telephone facilities.

Phase modulation.

The problem of phase and amplitude response at the low end of the frequency band may be overcome to some extent through the use of phase modulation. If a carrier signal with a frequency equal to the bit rate is used, and it is modulated by reversing its phase as the input changes from ONES to ZEROS, the pattern shown in figure 4 results.

In this waveform note that each ZERO is represented by one cycle of the carrier signal and each ONE is also represented by one cycle, but that the signal has been

inverted for the ONES. It is no longer necessary to have D.C. response in order to transmit this signal, and the problem of phase response at the low end of the band has been somewhat alleviated. However, it is necessary to transmit frequencies higher than the bit rate in order to interpret this signal properly at the receiver. The net result is that the overall required bandwidth has been widened by this approach.

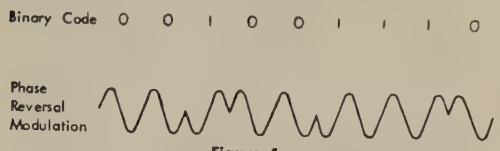


Figure 4.

Another type of modulation which might be used is one in which ZEROS are represented by no signal, and ONES are each represented by one cycle of the carrier signal.

This method of transmission, shown in figure 5, is sometimes called « raised cosine » modulation. With this type of modulation, a good phase and amplitude response is again required at the low end of the band, but the use of a clamping circuit in the receiver allows the relaxation of this requirement to some extent.

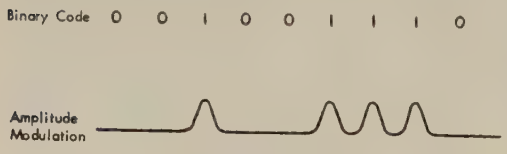


Figure 5.

Transmission of the three types of signals just described is not very satisfactory when regular telephone circuits are used as the communication medium. All three systems require a good amplitude and phase response over a bandwidth approximately equal to the bit rate. However, it is possible to modify the original binary signal so that the total bandwidth required for transmission is reduced.

Represent « ONE » by a crossover.

Instead of representing each ONE by a positive signal and each ZERO by a negative signal, suppose that the circuit represents each ONE by a transition, or cross-over from one state to the other, and each ZERO by no cross-over. The original binary information will then result in the waveform shown in figure 6. Passing the signal through a low-pass filter results in the lower waveform.

This digital modification may be obtained through the use of a very simple circuit. A signal which consists of a sharp pulse for each ONE and no pulse for each ZERO is sent into the input of a flip-flop counter. The output of the counter then consists of a transition every time a ONE appears. The band-

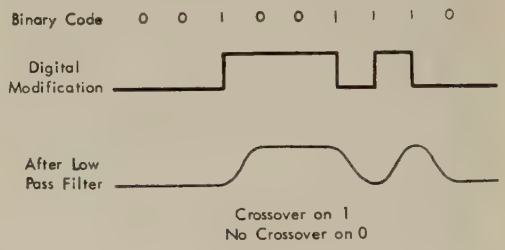


Figure 6.

width required for transmission of this signal has not been reduced below that required for the previous signals. However, an additional modification is now possible which will improve the situation.

In figure 7, note that the binary code signal drives the flip-flop and the flip-flop is connected through a low-pass filter as before. However, in this case the input of a shorted delay line is connected across the input to the low-pass filter. One of the properties of a short-circuited delay line is that a pulse transmitted into its input is delayed and reflected back to the input with its polarity inverted. Suppose, in this case, that the equivalent length of the shorted delay line is one half of a bit interval. Then a signal

which enters the delay line will come back out inverted and delayed one bit interval. A step function applied to the input of the shorted delay line will be converted into a rectangular pulse one bit in length. What happens when a modified binary code signal is connected to the shorted delay line is shown in figure 8.

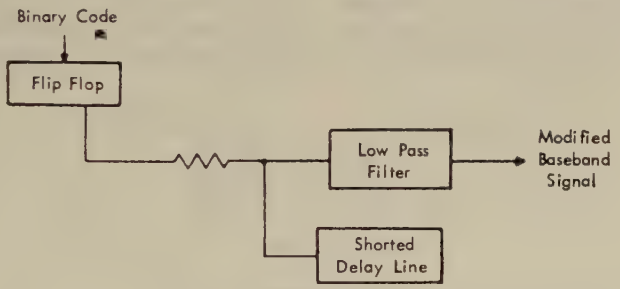


Figure 7.

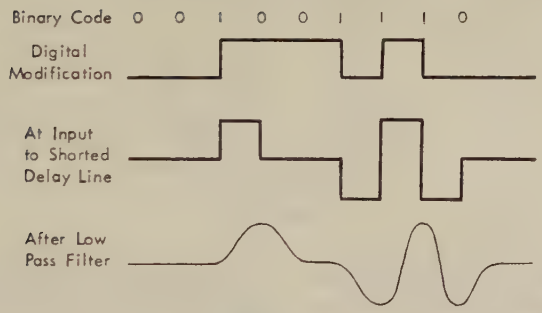


Figure 8.

The top waveform is the signal at the output of the flip-flop. When this signal is impressed, through a terminating resistor, on the shorted delay line, a new signal results which has three possible levels. A transition from minus to plus is converted into a single positive unit pulse, and a transition from plus to minus is converted into a single negative unit pulse. A steady state condition, either positive or negative, results in a zero level signal.

When this signal is compared with the original binary information, the ZEROS have all been converted to a neutral or zero voltage. The ONES have all been converted to unit pulses, but the polarity of these pulses alternates. The first ONE is a positive pulse, the second ONE is a negative pulse, the third ONE is a positive pulse, an so on.

The bottom waveform in figure 8 is obtained at the output of the low-pass filter, in which the cut-off frequency is a little higher than one-half the bit rate. The total bandwidth required for transmission has now been considerably reduced. It extends from about one-fifth of the bit rate to a little more than one-half of the bit rate.

Use narrow band-pass filter.

Since the components present in the transmitted waveform now cover a smaller part of the spectrum, a narrower band-pass filter may be used at the input to

the receiver. This should reduce the dificulties resulting from impulse noise and poor phase characteristics in the telephone facilities.

The signal to be transmitted has now been converted from a binary form to a ternary form, in which there are three levels; positive, negative, and zero. This means that some modifications are necessary at the receiver in order to recover the new transmitted signal. One advantage of the new digital modification is the primary current. Since the ternary signal has positive and negative pulses alternating, then every correctly received pulse will switch the core, first in one direction and then in the other. Every broad positive input pulse will result in a sharp switching core positive output pulse, and every broad negative input pulse will result in a sharp negative output pulse.

If a positive noise pulse appears immediately following a positive signal pulse,

Figure 9.

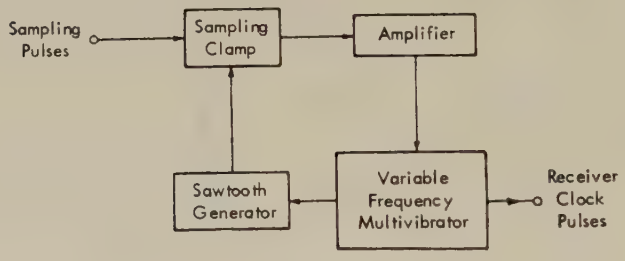


Figure 10.

immediately apparent. The signal may be inverted in the transmission medium, for example, by transformers, and no harm will result. The receiver will recover data from either polarity of signal with no modification.

A new passive circuit shown in figure 9, can be used to recover the binary information from the ternary signal received at the input to the receiving terminal. This circuit is called a switching core detector. It is simply a toroidal transformer in which the core is made from a material having a square hysteresis loop. Whenever the core primary current exceeds a certain critical value, the core switches suddenly from its previous state to the new state determined by the polarity of the switching core detector will not respond to the noise pulse, since it only responds to alternately positive and negative pulses.

A signal in which ONES are represented by sharp positive pulses and ZEROS by no pulses may be obtained simply by full wave rectifying the output of the switching core detector. Therefore, the original binary signal at the input to the transmitting terminal has now been recovered at the output of the receiving terminal. System operation is somewhat improved through the use of an automatic gain control system in which the gain of an amplifier at the input to the receiver is automatically adjusted to maintain a constant pulse

amplitude output from the full wave rectifier.

The pulses recovered from the receiver may be given exactly constant amplitude and width through the use of a regenerative circuit. In addition, they may be given exact timing by gating or strobing with a receiver clock pulse. This requires that some sort of automatic frequency control system be used.

Figure 10 is a block diagram of a typical automatic frequency control system. The normal method used to provide A.F.C. is to have a controlled frequency oscillator, which provides receiver clock pulses, operating under control of a phase detector circuit which compares the relative phases of the input signal and the signal from the local oscillator. However, in this case, the received signal is not a sine wave; in fact, it is not even a repeating rectangular wave. It might be said that the input signal consists of a series of pulses, where each pulse occurs at a fixed relative time reference, but in which the presence or absence of each pulse is equally probable.

Therefore, it is essential that the phase detecting circuit in the A.F.C. loop possesses sufficient memory, so that it will hold the previous control voltage during long periods of received signal in which no pulses occur. The required memory circuit is provided in this block diagram. A voltage is required, which is proportional to the phase difference between the variable frequency multi-vibrator signal and the input binary information pulses. The binary information pulses are used for sampling in a sampling clamp circuit. At the same time, a sawtooth waveform is generated by the output of the variable frequency multivibrator. The sampling pulses are used to take a measurement of the instantaneous voltage of the sawtooth waveform at the time of each sampling pulse.

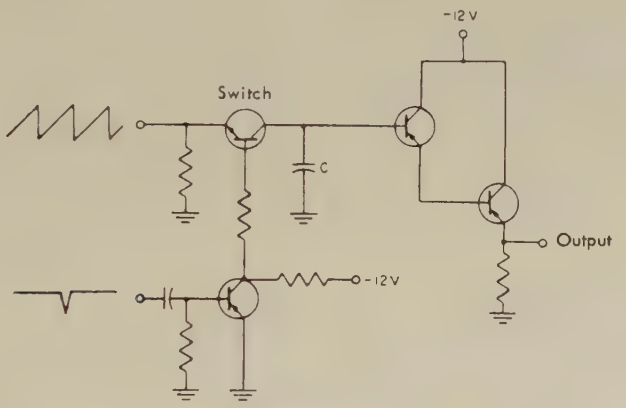


Figure 11.

The operation of the sampling clamp may better be understood by referring to the circuit diagram figure 11. In this circuit, one transistor is used as a switch. It is normally nonconducting, but is turned on through the action of the sampling pulses which are amplified and applied to the base of the switching transistor. The sawtooth waveform from the variable frequency multivibrator is connected to the emitter of the switching transistor. During the short interval in which the switch conducts, the capacitor C is charged or discharged so that the final voltage across it is equal to the instan-

taneous sawtooth voltage at the end of the sampling pulse when the switch opens. After the switch opens, the capacitor retains that voltage until it is again changed by the action of the switch. A two-transistor emitter follower reads the voltage across the capacitor without discharging it and provides a low impedance version of this stored voltage, which is amplified and used to control the frequency of the variable frequency multivibrator. This output control voltage is very nearly proportional to the relative phase angle between the sampling pulses and the sawtooth waveform.

Where telephone toll circuits are involved, another transmission problem is often encountered. This is brought about through the use of single sideband voice carrier channels. In this case, the carrier frequency of the transmitting terminal is not transmitted. Instead, the demodulating carrier is reinserted at the receiving terminal. Since the two carrier frequencies may not be exactly equal, the resulting demodulated output of the receiving carrier terminal may be translated in frequency, relative to the original input signal. While this translation causes very little trouble with voice signals, it can be disastrous as far as data is concerned.

One method of overcoming this problem is to use an amplitude-modulated subcarrier system. If some of the subcarrier frequency signal is transmitted along with the binary information, then it will also be translated by an equal amount and a subcarrier demodulator at the receiving terminal will recover the binary data without any overall frequency shift. One type of amplitude modulated subcarrier system which might be used provides vestigial sideband transmission. In this case, the equivalent of one sideband and some of the carrier are transmitted.

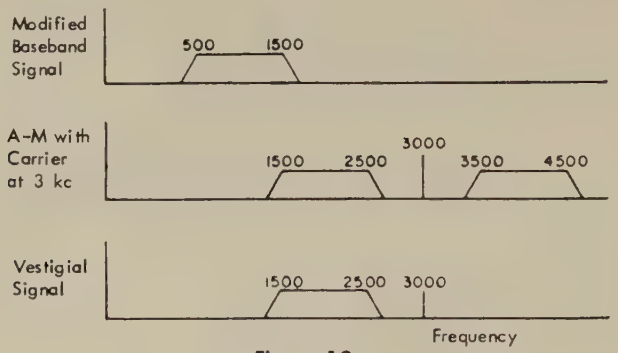


Figure 12.

Single sideband transmission.

In figure 12, a binary data rate of of 2 500 bits per second is used. The modified baseband ternary signal will occupy a band of frequencies from approximately 500 to 1 500 cycles per second. If the three kilocycle carrier is amplitude modulated, the result will be two sidebands, one from 1 500 to 2 500 cycles per second and one from 3 500 to 4 500 cycles per second. Passing this signal through an appropriate vestigial sideband filter leaves only the lower sideband and part of the carrier to be transmitted. Since frequency components near three kilocycles have been eliminated, amplitude and phase requirements of the vestigial sideband filter have now been somewhat simplified.

Compandors raise problems.

There is another problem which often appears in telephone toll circuits. This results from the use of compandors over which the transmitting and receiving stations have no control. A compandor is a device used to adjust the overall gain of the communication system in order to provide an improved signal-to-noise ratio. The time constant of the automatic gain control circuit is designed so that the system voltage levels may be adjusted at a syllabic rate. This is most appropriate for normal voice communications but may cause considerable difficulty when a data signal is suddenly applied to the telephone line.

Compandors are especially troublesome in systems which provide automatic error correction through retransmission of blocks of data. The data communication system should be capable of transmitting a block, then stopping to check the accuracy of reception, and then starting up to transmit a second block.

Compandors will cause little trouble if a constant amplitude signal is continually passed through the system. The ternary transmission signal and vestigial sideband amplitude-modulated subcarrier can be used to provide the necessary constant amplitude signal. If continuous ONES are transmitted through the system at all times when there is no data to be transmitted, then a constant amplitude tone will result. A data signal may be reinstated into the system at any time with very little change in amplitude of the transmitted signal.

During the verification interval after à block of data has been transmitted, continuous ONES may be sent out by the transmitting terminal. Since the required frequency spectrum has been reduced, there is now room for a tone signal, which may be used by the receiving terminal to verify accurate receipt of the previous block of data.

An experimental model of a data transmission link similar to the one described has been set up and operated over commercial telephone facilities. It should be remembered that this system is not intended for use under high random noise conditions. However, on a typical average grade telephone circuit with a signal-to-noise ratio of approximately 12 decibels, very encouraging performance has been obtained. The system has been tested using random characters, repeating characters, and long trains of characters.

For local telephone cable circuits where no single sideband voice carrier channels are involved, direct transmission of the modified baseband was utilized. Testing so far has indicated that an information rate of 5 000 bits per sec can be used with good reliability. The measured error rates of most of the tests have fallen between one error in 100 000, and one error in 1 000 000 transmitted bits.

2 500 bits per second.

For transmission through carrier channels, the amplitude-modulated subcarrier with vestigial sideband transmission has been used. Testing so far has been conducted in the laboratory and over relatively short commercial toll circuits. The results indicate that it appears quite feasible to transmit information at a rate of 2 500 bits per sec.

In addition to the equipment's ability to transmit data at high rates of speed over telephone facilities, two other features should be noted. One of these is its low cost. The basic simplicity of the technique used to modify the signal for transmission results in an uncomplicated circuit diagram and therefore an inexpensive piece of equipment. In addition, since there are very few components in each terminal and since printed circuit plug-in modules are used throughout, the equipment is very easily maintained in operation. System reliability is provided by the exclusive use of solid state components.

Several particular problems have been

selected for a concentrated effort in the near future. These are :

1) improved network design. This work involves not only studying the overall response of the complete data transmission system with the goal of improving its operation, but also the use of improved techniques for the design of the filters and equalizers;

2) receiver improvement to reduce the transmission bandwidth still further. Several new ideas are being tried in experimental circuits and a concentrated effort is being applied to the problems of overcoming phase distortion and improving the system's resistance to impulse noise;

3) more extensive toll test. There is a continuing program involving extensive testing of the present equipment over simulated and actual commercial telephone toll circuits. The effort is now concentrated mainly on increasing the length of these circuits.

The development program to provide new equipment which will result in improved transmission of digital information over telephone facilities, has led to several conclusions. Two basic disadvantages found in wire lines, impulse noise and poor phase characteristics can be overcome by reducing the bandwidth of the frequency components necessary at the input to the receiving terminal. This bandwidth reduction may be obtained through the use of a digital modification of the original binary signal, resulting in a ternary signal which is actually used for transmission. The results of tests with experimental equipment over actual commercial telephone circuits have been so good that the design program is being continued, and it is anticipated that additional improvements will be forthcoming in the very near future.

[625 .215 (52)]

Development of air spring trucks in Japan,

by Tadashi MATSUDAIRA.

(*Japanese Railway Engineering*, No. 2, March 1960.)

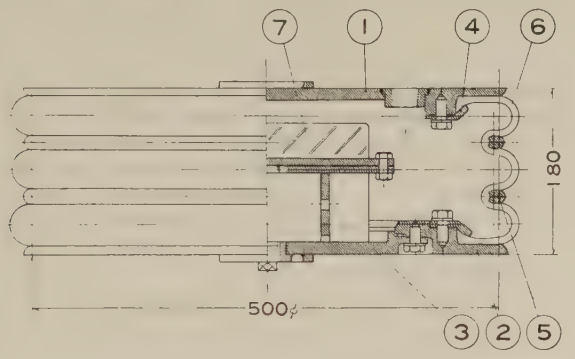
1. Introduction.

In the last several years rapid progress has been witnessed in the research into, and practical development of air springs in Japan; particularly its application to railway rolling stock has produced spectacular results. In the Japanese National Railways the crack trains such as the de luxe super-expresses « Kodama », « Asakaze », « Sakura », and recently some of the commuter trains as well, are made up of cars equipped with air springs and the excellent riding comfort given by these springs is highly appreciated by the travelling public. As of October 1959, the number of cars so equipped, including experimental units totals 290, of which 70 are passenger cars, 219 electric railcars, and 1 an electric locomotive. Meanwhile, on private railways, also, many cars equipped with air springs of diverse types are being operated regularly or experimentally. The number presently totals about 250 and is steadily on the increase.

The Rolling Stock Dynamics Laboratory of the Railway Technical Research Institute of the Japanese National Railways has, since 1955, been engaged in systematic studies on air-springs for vehicles. Valuable basic data on the design of air spring trucks have been furnished by the Laboratory and a series of experiments on cars with air springs was also carried out.

The present paper purports to outline the development of air spring trucks in

Fig. 1. Construction of Bellows Type Air Spring (for "Asakaze")



1. Upper plate
2. Lower plate
3. Lid plate
4. Sealing ring
5. Hoop ring
6. Rubber bellows
7. Stopper rubber

Japan and to give a brief account of informations and experiences gained through our theoretical and experimental studies.

2. Construction and characteristics of air springs.

Most of the air springs presently applied in Japan to railway rolling stock belong to the three-bulge bellows type. As a typical example the construction of that used for the « Asakaze » is illustrated in figure 1, a general view of the air spring as shows at the top of the article. The material of this bellows is a blend of natural and synthetic rubbers reinforced with twoply rayon cord. When the car is under a capacity load, the static pressure reaches about 3.1 kg/cm², with the static load being 6.50 t and the internal volume about 24.7 *l*.

In this type of air spring, the load P and the displacement x from a specified normal position can be correlated by the following formula :

$$P = \left(\frac{p_0}{(1 - x/H_{e0})}\pi - p_a\right)A_0\left(1 + \frac{Cx}{nD_0}\right), \quad (1)$$

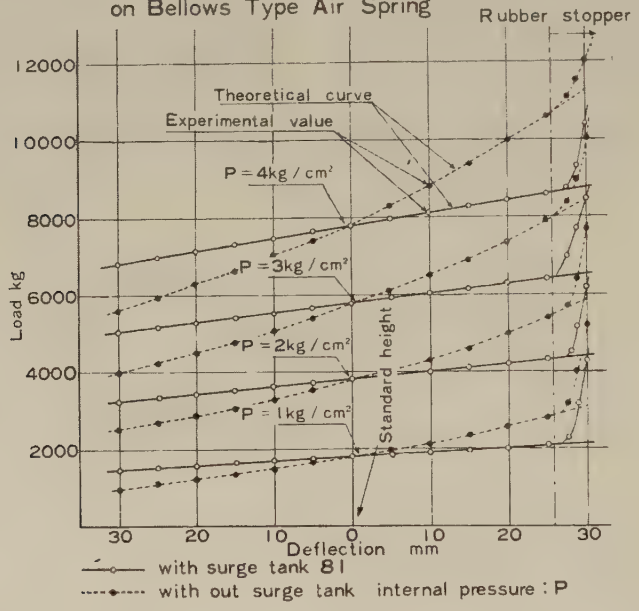
where p_0, A_0 and D_0 are respectively the internal pressure (absolute pressure), the area subject to pressure, and its diameter, under standard conditions; p_a the atmospheric pressure; H_{e0} the effective height of the air spring, in the case, with the internal volumes stated as V_0 it may be approximated by

$$H_{e0} = V_0/A_0,$$

π the polytropic index of air, equal to 1 under isothermal change 1.4 under adiabatic change, the latter value being experimentally found appropriate when the vibration of cars is more than 1 cps or so; n the number of bulges in the bellows; C a constant depending on the manner of anchoring the end of the bellows; (in the case of fig. 1, it may be presumed that $C = \pi$).

When the air spring is connected to an auxiliary tank, the tank volume V_T should be added to V_0 in the case of static load; when a throttle is provided between the air spring and the tank, the value of H_{e0}

Fig. 2. Results of statical load test on Bellows Type Air Spring



under dynamic load becomes a function of frequency and in the case of frequency being zero, naturally it is equal to $(V_0 + V_T)/A_0$, approaching V_0/A_0 as the frequency draws to infinity.

The spring constant at standard height of spring is expressed by

$$k_0 = \left(\frac{dP}{dx}\right)_{x=0} = \frac{xp_0A_0}{H_{e0}} + \frac{C(p_0-p_a)A_0}{nD_0} \quad (2)$$

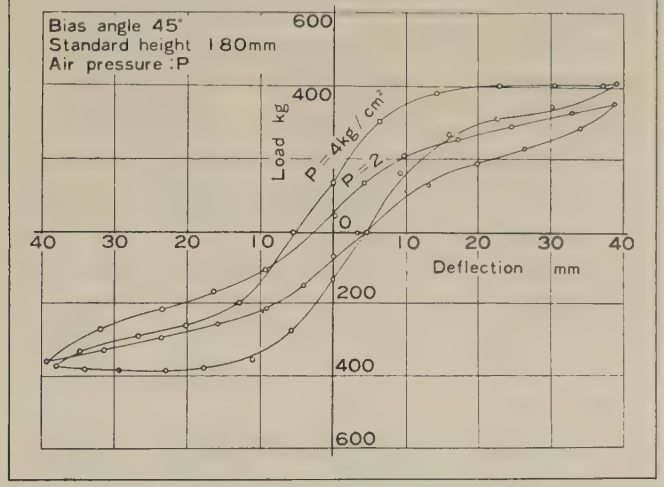
The first term in the above formula concerns the variation in internal pressure due to displacement and the second term the increase in area.

It follows from this formula that in order to lower the spring constant of this type of air spring, not only should the first term be reduced through increase of effective height by increased internal volume, but also the second term should be reduced through increase in the number of bulges. However, to increase the number of bulges will entail a problem of buckling of the bellows; therefore the practical limit is 4 bulges. Another effective means of minimizing the second term is improvement of the shape of the clamping metal at the end of the bellows so as to give a smaller value of C. This idea eventually leads to adoption of a diaphragm type of air spring.

Figure 2 shows the results of a static load test on the air spring as illustrated by figure 1, in which the solid curve represents the calculations by the above formula. There is a good agreement between the experimental and the theoretical values.

Figure 3 gives some of the results of lateral displacement tests on different air springs belonging to the same type. As evidenced by this figure, in the case of lateral displacement the curve has a gradual fall, contrary to the case of longitudinal displacement; that is, the displacement sharply increases when the lateral force exceeds a certain value. This is due to buckling of the bellows. For this reason, if this type of air spring is to be effective in the lateral direction, too large a displacement should be avoided; besides, combined use of a rubber stopper is necessitated. The hysteresis curve for lateral displacement produces a fairly large loop area owing to the sliding friction between the rubber membrane and the ring. Though it is known that the spring constant and the buckling limit in this lateral displacement

Fig. 3. Results of lateral displacement tests Bellows Type Air Spring (for "Asakaze")



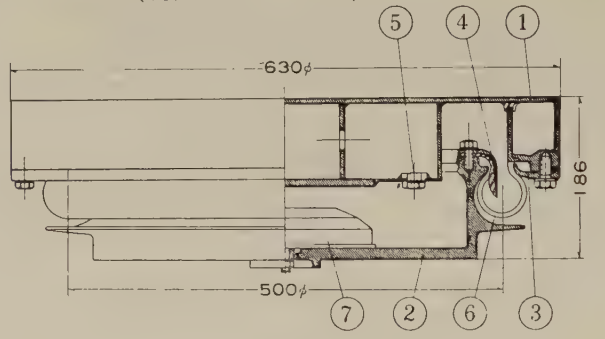
are influenced by the bias angle of cord as well as the configuration of the bellows, the theoretical calculation of these factors is too complicated to be worked out at least for the present.

In addition to the bellows type mentioned above, various other types are in use. The main object of such modifications is to improve the lateral displacement characteristic. Two variations of this type are available; one with the coil spring exposed outside the rubber membrane and one with it embedded in the membrane.

Figure 4 explains the construction of the so-called diaphragm type which recently underwent an endurance test in the field. In this type the shapes of the piston periphery and the cylinder skirt coming in contact with the rubber diaphragm are appropriately formed so that the second term of formula (2) will reflect changes in displacement, that is, the load-displacement curve may flatten out in the neighbourhood of the standard height of the spring, while its gradient will increase with the increase in displacement. Thus, under normal conditions, the spring constant is made small enough to produce good riding comfort and at the same time a large displacement is prevented to ensure the stability of the car. Figure 5 shows the results of the static load test on this type of air spring.

As for the durability of these air springs, the bellows type is satisfactory. The rubber bellows in the early stage of its development was disfigured with ozone cracks, but not a single case of air leakage through the cracks has been reported. Such cracks have been successfully eliminated by selection of the proper material. In the diaphragm type fatigue strength poses a problem in automobiles which are heavily subject to vibrational displacement, but probably no problem in railway vehicles which are less subject to it. This problem is now under experimental study.

Fig. 4 Construction of Diaphragm Type Air Spring (for TR90 Truck)



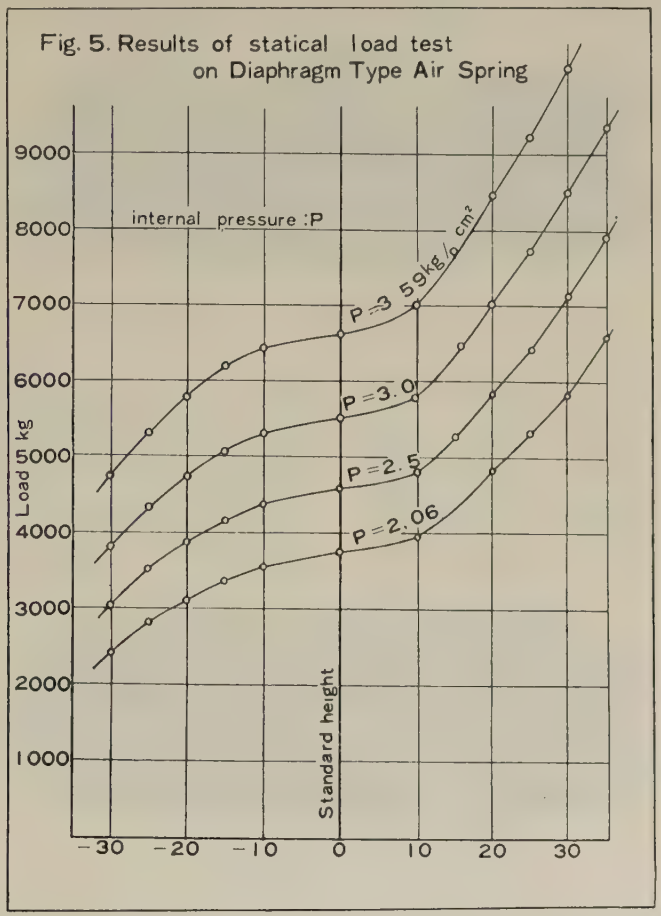
1 Air tank
2. Piston
3. Outer retainer
4. Inner retainer
5. Throttle
6. Diaphragm
7 Stopper rubber

3. Actual examples of air spring trucks.

Types of trucks so far built in Japan with air springs total an astonishingly large number. The most typical ones have been selected for description in sequence of their development.

The first air spring to be tentatively put in service in Japan was KS 50, an electric railcar truck for Keihan Electric Railway built by the Kisha Seizo Kaisha, in which the axle spring was replaced with an air spring. Otherwise the car is similar to the conventional all coil spring type. The bright prospect for practical development of air spring trucks and a wealth of valuable data for future designing.

To use an air spring as axle spring presented no trouble from the vibrational point of view, but there were inevitable drawbacks with air springs such as increased



auxiliary tank occupied the space enclosed by side sills and cross beams. The automatic height control valves are installed diagonally, one each on both sides between the axle box and the side sill. The new truck was superior to the conventional coil-spring truck with respect to reduction in both vibration and noise, and provided a number required, vulnerability of the automatic height control valve and moreover, occasional impossibility of halting the action of the valve at time of braking or at spots with a sharp cant difference between two axles. For this reason, in subsequent designs the air spring has come to be used exclusively as a bolster spring.

The first attempt was represented by the KS 51 truck also built by the Kisha Seizo Kaisha following KS 50 in figure 6. In the improved truck, only the bolster spring of the conventional, all-coil spring truck with swing hanger, was substituted with an air spring. Officially adopted for use in the cars for the super express electric train of

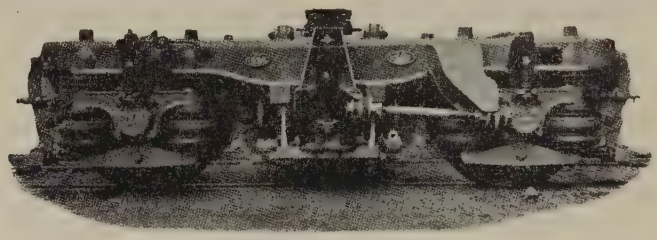


Fig. 6. — KS 50 Type. Manufactured in 1956 by Kisha Seizo Kaisha for Keihan Electric Railways.

Keihan Electric Railway, it has won great popularity among the passengers. At present most of the air-spring trucks widely adopted in Japan belong to this type. As representative trucks of this type, photographs of the TR 55 truck for « Asakaze » of JNR and DT 23 for « Kodama » are shown in figures 7, 8 respectively; in the former the auxiliary tank is located inside the side sill and in the latter, inside the upper bolster. The ratio of the interior volume of the bellows to that of the tank is 3.3 in the former and 2.3 in the latter; in both cases a throttle 15 mm in diameter is inserted between bellows and tank. In addition, an oil damper is jointly used, with a damping coefficient of 20 kg/cm/s in the former and 40 kg/cm/s in the latter, which are approximately equal to half the value for coil springs. The size of the throttle between the air spring and tank and the optimum damping values of oil dampers have been established through theoretical analysis and further confirmed by experimental results. Inasmuch as the Japanese National Railways is of narrow gauge, the lateral stability of rolling stock is a perennial headache and both trucks are equipped with stabilizers utilizing a torsion bar.

Viewed from the construction aspect, all of the air-spring trucks described above are nothing but the common type trucks with axle springs, bolster springs and swing hangers that have their metal springs replaced with air springs. The principal object namely to improve the vibrational riding comfort has thus been accomplished with satisfaction. In the next stage of progress, efforts are being directed towards simplification of truck structure. As a result various types of unique design departing from the

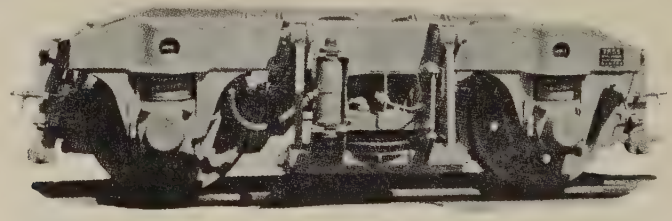


Fig. 7. — TR 55 Type. Designed and used by JNR (1958).

fixed concept of trucks in the past and doing full justice to the characteristics of air springs have been constructed on an experimental basis. Most notable among them is the following.

Figure 9 shows an example of an air spring truck for railers which is greatly simplified in construction. In this example the lateral elasticity of air springs is exploited so as to abandon the swing bolster, while the incomparable softness of air springs is counted upon so as to dispense with the axle spring. Further with reliance on the effect of the orifice between the air spring and the auxiliary tank located inside the side sill, even the oil damper is abandoned. The only addition is a stabilizer using a torsion bar for the purpose of eliminating the rolling caused as a result of the air spring on both sides being connected. There is only one automatic height control valve installed in the centre of the upper swing bolster.

In the case of air spring trucks, reduction of the spring system to one degree of freedom with exclusive reliance on the damping effect of air such as in this example may somewhat aggravate the chatter, but not to any serious extent, the test results on this truck confirm that such chatter might be tolerated in commuter trains.

In the case of a motored railcar, the truck construction is rather complicated due to necessity of installing the motor above the spring. Figure 10 shows an example of motored railcar truck equipped with an air spring; the motor, not shown in the photograph, is mounted on the beam and supported by anti-vibration rubber between the side sills on both sides. This truck is not provided with an anti-rolling device. The oil damper is provided to deal with lateral movement only and oil damping against vertival movement is omitted. In consideration of abatement of longitudinal vibration the bolster anchor is alined with the central plane of the axle and the centre plate is located as low as possible. In the

Fig. 8. — DT 23 Type. Designed and used by JNR (1958).

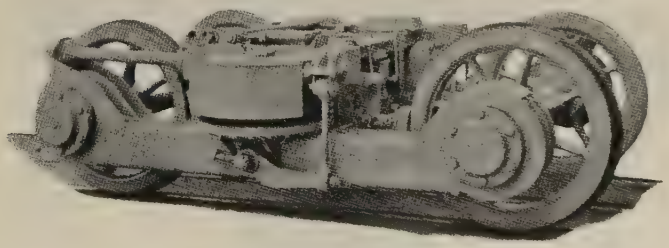


Fig. 9. — KH 15 Type. Manufactured in 1958 by Hitachi Ltd. for Sagami Railway.

case of air spring trucks, particularly motored railcar trucks, it is quite often found that the abatement of vertical vibration makes the longitudinal vibration, which was previously not too noticeable, more conspicuous. For this reason, special attention should be paid in designing to the height of the bolster anchor installation and the stiffness of its rubber fixtures.

Figure 11 shows another example of a similar truck. In this instance, the axle spring is retained for better vibrational riding comfort and for installation of the motor above the spring. The top of the air spring touches the car body and the bottom is fixed to the bolster which is mounted on the cross beam of the truck so as to be freely rotary on the centre plate. The interior of the bolster serves as auxiliary tank and both sides of the bolster are consolidated with the car body through bolster anchors. Between the body and the bolster there is an oil damper which reacts only to the lateral movement. The load on the car body is transmitted to the truck frame, mostly through the centre plate and partly through the side bearing immediately below the air spring of the bolster.

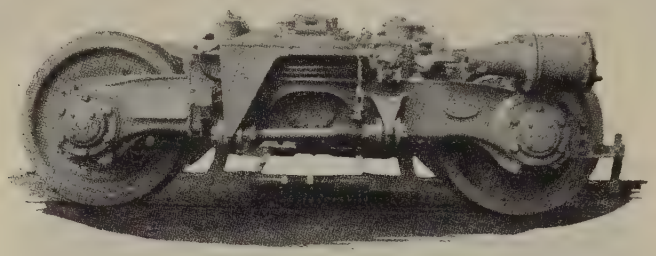


Fig. 10. — KS 55 Type. Manufactured in 1959 by Kisha Seizo Kaisha for Keihan Electric Railway.

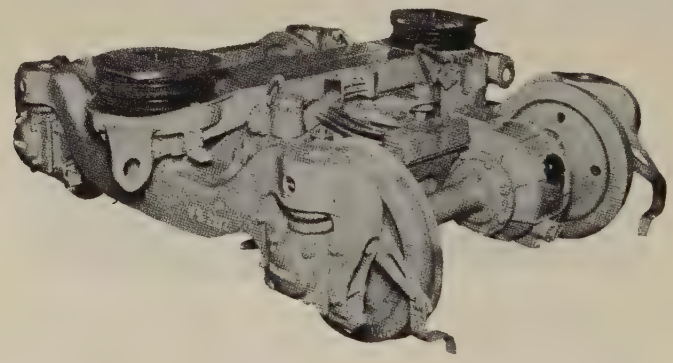


Fig. 11. — FS 207 Type. Manufactured in 1959 by Sumitomo Metal Industries for Hanshin Electric Railway.

These two represent the exploitation of the lateral elasticity of the air spring with consequent elimination of a swing hanger mechanism. Experimental results show that there are no indications that lateral vibra-

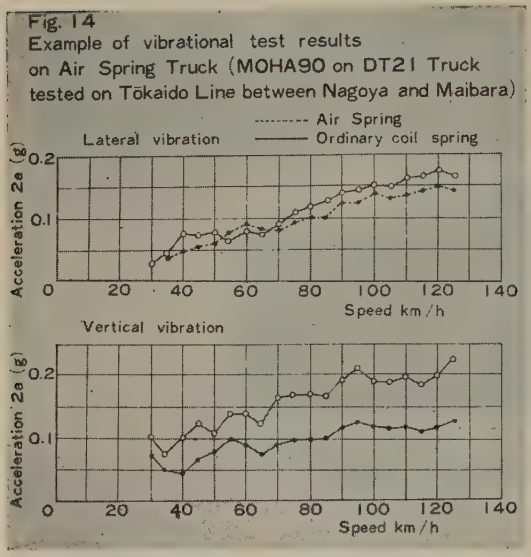
tion of the car body is particularly aggravated by adoption of these trucks. It is presumed that at least with speeds up to 110 km/h, this type can be used with satisfaction; the only precautions to be taken in its employment are to install the air springs as high as possible and space them as wide as possible to prevent rolling and, if necessary, to provide some appropriate stabilizing device.

Lastly, two types of new air spring trucks developed for testing purposes by the Japanese National Railways are shown in figures 12 and 13. Figure 12 is DT 90M, intended for suburban commuter trains. Like the truck KS 55 shown in figure 10, it has no swing bolster hanger nor axle spring. But, whereas in KS 55, both of the side sills are connected together with a frame which has small resistance to torsion, and the air spring is directly mounted on the side sill, in DT 90M these side sills are linked through anti-vibration rubber with an intermediate frame and then the air spring is mounted over them. Of course the motor is attached to this intermediate frame.

Fig. 12. — DT 90 M Type. Experimental truck manufactured in 1959 by Kinki Sharyo Co. for JNR.

Figure 13 shows a passenger car truck designed for retaining the swing hanger. The air spring adopted is the diaphragm type shown in figure 4; the top, that is, the cylinder side, is fixed to the car body and the bottom i. e. the piston side, to the swing bolster. The load of the body is transmitted from the air spring vertically through the swing bolster and its hanger to the side sill. The body and the bolster are linked by the bolsters in the lateral and longitu-

Fig. 13. — TR 90 Type. Experimental truck manufactured in 1959 by Hitachi, Ltd. for JNR.



dinal directions respectively. The longitudinal force is transmitted from the bolster centrally through the link mechanism to the cross beam.

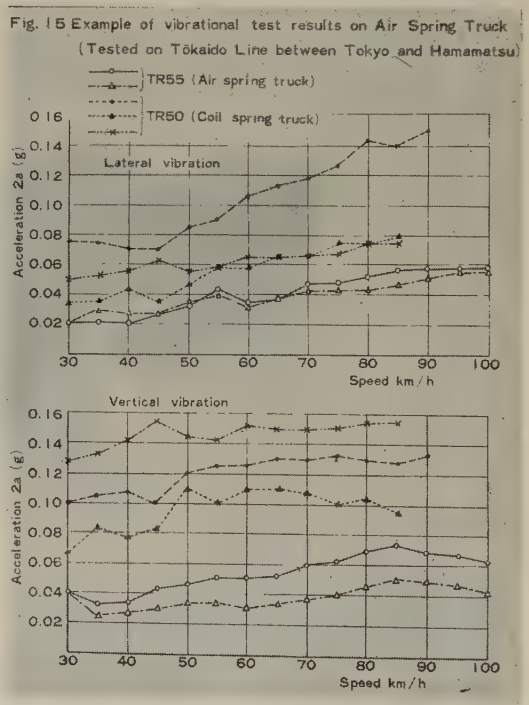
4. Test results on air spring trucks.

Some of the test results are cited to illustrate the excellent vibrational characteristics of air spring trucks.

Figure 14 shows how the vibrational characteristics are improved in the electric railcar, Type MOHA 90 equipped with a common all-coil spring truck DT 21 when the bolster spring of the truck is replaced with an air spring. The vibrational acceleration of a car body with air springs is reduced in the vertical direction about 40-50 %, in the lateral direction about 10-20 %, as compared with metal springs. Figure 15 compares vibrational acceleration of car bodies between the de luxe passenger car with air spring trucks used on the « Asakaze » and a common type mounted on the latest model of truck with metal springs. It is evident from this figure that a remarkable improvement in the vibrational characteristics of car bodies has been achieved through adoption of air spring trucks.

The contribution of air spring trucks to the abatement of noise in the train is also appreciated; no precise measurement data are available yet, but it may easily be recognized that the sleeping car with air springs offers a favourable contrast to the one with metal springs.

Running tests have been conducted on TR 55 trucks for « Asakaze » and DT 23 for « Kodama » to see if they are still safe in operation in case the air is exhausted from the springs owing to some untoward accident. Naturally there was a substantial increase in the vibrational acceleration of the car body, particularly more chattering. On the whole, it has been ascertained that the situation is more or less the same as with trucks equipped with conventional laminated leaf springs, and no particular alarm need to be felt regarding safety of operation.



[625 .141 (73)]

Asphalt-coated ballast.

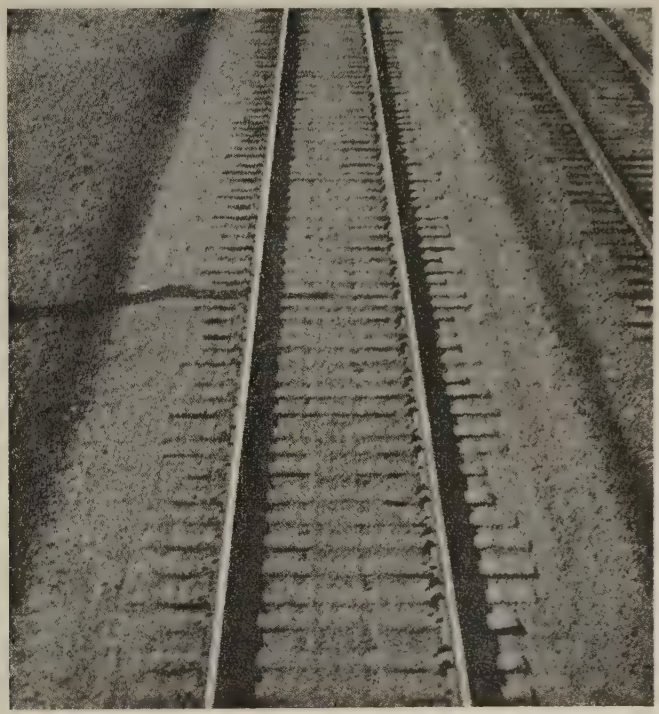
Potential benefits spur further tests.

(*Railway Track and Structures*, July 1959.)

Earlier tests have suggested that definite savings in maintenance costs are possible through the use of asphalt-impregnated ballast.

Now those possibilities are to be further explored through additional test installations sponsored by The Asphalt Institute and the Engineering Division, A.A.R.

But something new is to be added this time: at least some of the test sections will be located on track laid with continuous welded rail, with 78-ft. and 117-ft. rails, and with tight joints as well as with conventional joints.



Maintenance data for asphalt-treated roadbed (left) on the Santa Fe near Barstow, Calif., will be compiled and compared with those for the untreated ballast (right).

As far back as 1926, railroad engineers have been experimenting with asphalt in an effort to exclude water and fouling materials from the ballast. This year, encouraged by the performance records of these earlier tests of asphalt-treated ballast, a number of new test sections are being established.

Undertaken primarily to determine the economy of using asphalt-treated ballast on track laid with fewer rail joints, the new tests are being sponsored by The Asphalt Institute and the Engineering Division, A.A.R. They will be located on track laid with continuous welded rail, with 78-ft. and 117-ft. rails, with tight joints and with conventional joints. Several different types of ballast will be applied in the test sections, including crushed gravel, crushed limestone, crushed blast-furnace slag, crushed chat and volcanic cinders.

Two specially equipped cars for the asphalt treatment of ballast were developed and constructed. One, the asphalt distributor unit, was built on a flat car and was equipped with a pump, a hot-oil system for maintaining heated supply lines, a tachometer for governing the asphalt distribution, and spray bars. Two of the latter are of the outrigger type for covering the track area outside the rails, resulting in a total swath of about 14 ft.

A fan-shaped spray pattern assures distribution of the hot asphalt cement while specially designed shoes prevent this material from getting on the rail treads. A swinging 22-ft. overhead boom at each end of the car permits a continual supply of asphalt cement to be drawn from tank cars on each end.

Distributor car is assured an adequate supply of asphalt by provision of overhead pipe connections to adjacent supply cars.

Rotary flinger spreads stone.

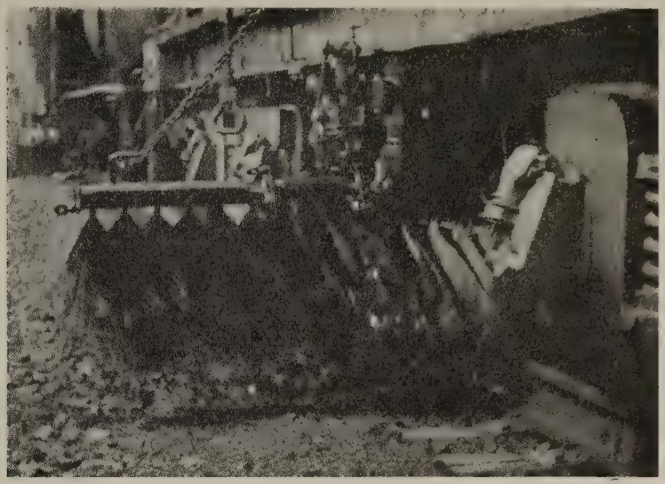
The other car is the stone-spreading unit. This is a conventional bottom-dump hopper car of 50 tons capacity. A gas-engine generating plant is mounted within the car between the two hoppers. This furnishes electric power for driving two motors used for flinging the screenings. A rotary flinger is mounted on each side beneath one of the hoppers and casts the stone toward baffle plates. From there the stone is spread over that part of the track area which extends from about the ends of the

ties to 7 ft. out from the center line of the track. The second hopper is employed to feed stone over the track area between the tie ends.

Used on Santa Fe.

The first road to avail itself of this equipment on a loan basis was the Santa Fe. This road scheduled the application of six test sections, totaling 25 miles, during April and May. These included a two-mile section near Barstow, Calif., one five miles long near Peach Springs, Ariz., a section served principally as a blotter course but it also filled the larger voids.

The distributor car made two passes over the test section to achieve the specified rate of application. The capacity of the asphalt pump was limited to 1 gal. of asphalt per sq. yd. when traveling at a speed of 2 m.p.h., or 2 gal. per sq. yd. at 1 m.p.h. It was found impracticable to throttle down the work train speed to a constant forward movement slower than 2 m.p.h. It is believed that a larger pump or the use of dual distributor cars will overcome this problem.



Hot asphalt is spread by outrigger and undercar spray bars. Specially designed shoes prevent the rails from being coated.

near Albuquerque, N.M., and others near Topeka, Kan., Marceline, Mo., and Williamsfield, Ill. It is expected that other roads also will set up test installations of treated ballast during the current year.

The installation at Barstow was made on a stretch of track recently relaid with heavier rail and then reballasted. The asphalt spray, 85-100 penetration grade, was applied at a rate of 1 1/4 gal. per sq. yd. It penetrated into the stone ballast to a depth of more than 2 in. The cover stone, applied at the rate of 10 lb. per sq. yd.,

Tests should answer questions.

It is expected that the new tests will answer some of the questions now in the minds of trackmen relative to asphalt-treated ballast. For instance, the tests on the Illinois Central were carried out when tie renewals and much of the other track work were done manually. The new tests will reveal the man-hours necessary for making tie renewals and surfacing track with today's equipment.

Other questions are :

What effect will modern tie-removal machines have on the asphalt coating?

What effect will the asphalt have on the track machines?

How will spot surfacing be done?

In view of the necessity of resealing the asphalt coating, will the tracks be maintained to the same standard as adjacent track?

asphalt-coated stone ballast. This installation was located on the road's east bound high-speed main track along the station platform at Byran, Ohio.

For this installation the old cemented ballast was first dug out and new stone ballast, coated with emulsified asphalt was placed to a depth of 8 in. under the

Two passes were made over the test section to achieve the specified rate of application of 1 1/4 gal. per sq. yd. This penetrated the stone ballast from 2 to 3 in.

WHAT EARLIER TESTS HAVE SHOWN.

There have been two major service tests of asphalt-treated ballast in the past, one on the New York Central and the other on the Illinois Central. Here are details of these tests and what was learned from them:

On the New York Central.

The installation on the N.Y.C., made in 1926, was a 600-ft. test section of emulsified-

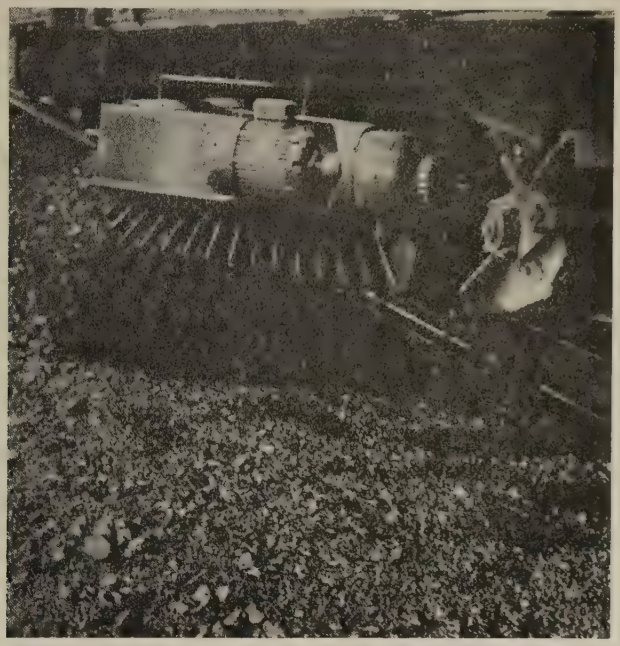
crossties. This ballast was tamped under and around 7-in. by 9-in. ties which had been painted on the sides and ends with emulsified asphalt. A top coat, 1 in. thick, was placed over the ballast to fill the voids and completely seal the surface. This coat was a mixture of emulsified asphalt and wet sand.

The N.Y.C. kept records of the track work performed on this test section, which included the man-hours expended by both the foreman and laborers, material and equipment, as well as the type of work

performed. The road reported that no work was done or any minor repairs made until August 1940 — 14 years after the initial installation — at which time the seal coat was removed in a few places where it had been shattered and was replaced with new material. It was noted that some track creeping had opened up cracks between the edges of the ties and the seal coat. These were filled with a mixture of sand and asphalt.

Labor cost was low.

The cost of maintaining the track in the 600-ft. test section was found to be relatively low. For the five years 1940-1944, inclusive, an average of 42 man-hours of the foreman's time, 108 man-hours of the sectionmen's time, 0.9 cu. yd. of sand, 0.4 cu. yd. of stone ballast and 192 gal. of emulsified asphalt were used annually on the maintenance of this track.



Stone aggregate of small size is spread evenly over the treated ballast by rotary flingers installed beneath bottom-dump hopper cars.

During the years 1941 to 1944, inclusive, other minor ballast repairs were made. These included the raising of a few low joints, the tightening of some loose ties and the renewal of some ballast in the cribs east of a highway crossing. New rail and fastenings, except plates, were laid through the test section in 1942. Rail-relay work was not included in these averages.

Reports on this test were favorable. The track had good riding qualities under high-speed operation. It stayed in good line and surface — in fact, it preserved these qualities more than conventional stone ballast. Also, because emulsified asphalt was

used instead of the hot-mix type, the ballast mixture remained pliable so the track could be worked whenever low spots developed and the seal coat could be restored.

However, apparently there was some speculation among maintenance officers that perhaps it was not necessary to treat all of the ballast in the section with asphalt. Sooner or later the crossties would wear out and the renewals no doubt could be made easier in conventional ballast than in asphalt-treated ballast. This engendered the idea of providing an asphalt seal coat as an umbrella over the ballast section. It was reasoned that the elimination of water and foreign matter from the ballast would produce a dry roadbed and uniform track conditions that would reduce maintenance.

On the Illinois Central.

Because of this interest, the Illinois Central installed a 1/2-mile test installation of asphalt-penetrated ballast with a seal coat near Manteno, Ill. This test was sponsored by The Asphalt Institute and received the cooperation of the Engineering Division research staff of the A.A.R.

In setting up this test section, the ballast was first cleaned, the track raised 6 in. on new ballast, all necessary tie renewals were made and new 131-lb. rail laid. After the track was tamped, Texaco No. 96 asphalt paving cement, heated to between 275 and 350°, was applied by a distributor truck mounted on the rear of a flat car. Following the asphalt application, a layer of limestone screenings was spread, broomed and tamped. A second application of asphalt and the seal coat aggregate was spread over a swath 12 ft. wide. About 7 200 gal. of asphalt were used, resulting in a penetration of from 3 to 4 in.

Following the installation, the Illinois Central maintained records of the labor and material required to keep the test track up to the desired standards.

The majority of the labor was required for restoring surface. Appreciable lining operations were required only one year in the 10. The surfacing procedure consisted of what was called « end paddling ». This involved the cutting away of the asphalt-impregnated ballast from the ends of the ties, jacking the track to the required grade, and inserting chats or screenings under the ties by means of a long smooth steel blade. In 1948, this procedure was varied to permit the injection of a sand-cement slurry under the ties through pressure supplied by a small mud-jack.

In addition to the labor requirements, the test section required additional asphalt and screenings for resealing the surface. Annual requirements varied from 600 to 1 000 gal. of asphalt and from 10 to 20 cu. yd. of screenings for the period 1947-1952 inclusive.

Committee reports favorably.

After an inspection in the summer of 1953, it was agreed that the test section had fulfilled its life and that conditions were such that an out-of-face surfacing was required. The A.R.E.A. Roadway and Ballast committee concluded that asphalt-treated ballast is practical and beneficial. It also concluded that the economic life of this test section was seven years, because the section labor required during the last three years of the test period was in excess of that for the entire division on a per-mile basis. It was reported that the track drained well, that dust and cinders were kept out of the ballast and that there was less pumping than on conventional track. In general, the track reportedly rode well and the asphalt ballast was effective in maintaining line.

An interesting observation made by the Roadway and Ballast committee was that the greatest saving was in crossties. The seal coat sealed the checks and splits, prolonging the life of the ties to the extent that renewals on this section were half of those on adjacent track.

Experience with this test track showed that the maintenance work required was primarily centered at the rail joints. On this evidence it was pointed out that the economic life of asphalt-treated track would be materially increased by the use of continuous welded rail.

[656 .25 (73)]

Gangs do signal maintenance,

by V. P. Shepardson

Engineer Signals and Communications Richmond, Fredericksburg & Potomac.

(*Railway Signaling and Communications*, February 1960.)

Richmond, Fredericksburg & Potomac has been using gangs for signal maintenance work for four years. Using gangs instead of signal maintainers on individual territories has proved successful on this 110-mile mainline railroad. Editor's note : Mr. Shepardson spoke on gang maintenance at the Signal Section convention in October at Washington. This article contains much of his talk, plus additional material prepared especially for Railway Signaling and Communications readers.

We obtain high standards of maintenance by using gangs instead of signal maintainers assigned to individual territories. We have had the gang maintenance system for four years, and it meets our requirements.

While each man in the gang is an all-around signalman, some become experts on different phases of modern signaling. Thus we utilize these individual talents or specialties to the best advantage. For example, a man may become an expert on adjusting coded track circuits, another on carrier circuits, crossing gates, etc. If trouble occurs or repair is needed, the best suited man can be sent to do the job. We have these specialists in each gang, so they go only in the territory covered by their gang.

Traffic control all the way.

Before getting into the details, such as how many men are in each gang, etc. I had better tell you something about R.F. & P. signaling. We have 100 % traffic control from Richmond to Washington, 110 miles of multiple track mainline. Cab signaling and automatic train control are in service for bi-directional running. Except at interlockings, wayside signals are in service on each track for right-hand running only. Traffic locking is in effect between all interlockings, remote and locally controlled. These interlockings total 17, and in addition we have four remote control yard switch layouts. All mainline hand-throw switches are equipped with electric locks. All high signals and most dwarf signals are the colorlight type. Some new two-unit searchlight dwarf signals are being installed to replace bridge-mounted colorlight signals.

At Alexandria, Va., just across from Washington, we have a large retarder classification facility known as Potomac yard. There are two hump yards : 1) the northward hump yard of 49 classification tracks with power switches and manual retarder controls, and 2) the southward hump yard which we are rebuilding. This yard has 39 class tracks, automatic switching, radar speed control for automatic control of the master retarder and pushbutton speed selection on the group retarders. In rebuilding the yard, we did not have enough room for the required length of tangent and curve track on which to make rolling resistance measurements essential for automatic control of the group retarders.

In addition to highway crossing protection equipment, interlockings and other standard signal facilities, our gangs maintain two hotbox detector installations. One detector is about 30 miles south of « Pot » yard (Alexandria) to check southbound trains after leaving the yard. The other detector is 30 miles north of Richmond,

and checks northbound trains. Wire line carrier brings the detector signals to recorders in the Richmond dispatcher's office.

Do all types of signal work.

Our gangs do all types of signal construction and maintenance work. Highway crossing protection, interlockings (new, consolidated and modernized), and pole line relocation, construction and maintenance are some of the many and varied facilities covered by these gangs. At Potomac yard joint maintenance work is carried on with the communications men. For example, the radar units are replaced by signalmen, but are repaired by F.C.C. licensed communications men.

Of the four gangs, three work along the railroad, while the fourth is now engaged in construction work in modernizing the southbound hump and class tracks at Potomac yard. This yard construction gang and another gang are headquartered at Alexandria, Va. The other two signal gangs are headquartered at Fredericksburg and Richmond.

No mainline track walkers.

We have no mainline track walkers. To patrol our mainline we have four men working in pairs — a signalman and a track inspector. Each pair rides a track motor car and covers 25 miles of line every day. One pair is headquartered at Doswell, Va., M.P. 22 (north of Richmond). The other pair works out of Quantico (M.P. 79). In addition to inspecting rail bonds, insulated joints, track, switches, pole line and right-of-way structures and facilities, they work together in making switch adjustments and switch obstruction tests. The signalman carries rail bonds with him and replaces bonds when necessary. (We use a Copperweld, 7-strand, 53-in. plug type bond that rides on top of the joint bar bolts, but under the lip of the bar.) These men do any work they can do, the rest is reported to signal or M./W. supervisor for gang maintenance.

A foreman is in charge of each gang, and assigns the work to be done each day. The men are signalmen or assistants, we have no helpers. In addition to the foreman, each gang has a lead signalman. The size of the gang depends on the work to be done.

We equip each gang with a one-ton stake body truck and two half-ton pickups. Each gang carries portable telephones that can be hooked on the message or dispatcher's circuit. For pole line work, the signal gangs help the communications men. We have one pole line truck especially for this work. It is a four-wheel drive truck with an A-frame, pole hole augur and a winch. It is equipped with two-way radio operating on our train-to-wayside frequency. The dispatcher can keep in radio communication with the truck at all times through our wayside radio stations. We have two signal shops: one at Potomac yard and the other at Fredericksburg. Each shop is under the respective gang foreman, and he assigns men to shop work as required. One gang has a relay repairman.

Avoid routine.

The word *routine* when used with signal maintenance is a rather meaningless word that to me could best be defined as *rut*. Any work performed on a *routine* basis, whether the work is needed or not, is wasted effort. A detailed study of signal faults will indicate how effective our maintenance has been, but will not indicate if our *routine* maintenance has been carried to the point where the cost becomes excessive for the results obtained.

If our *routine* schedule is on the heavy side, how will we know until we have tried that we could get along on half as much? There are two extremes on almost any type of *routine* and neither is always correct. It would seem that in either case, it is worth a little deviation from what we have been doing just to convince ourselves that we are right or that we have been wrong all the time.

I once saw this heading on an article: « Maintenance. — The Secret of Cost Re-

duction ». Why this should be a secret I will never know unless because of railroad accounting methods, a large part of signal maintenance expenses is hidden in other accounts. This may be good, but to determine actual maintenance costs for useful comparison, extra bookkeeping is required by the signal department. But this can be well worth the effort.

A detailed examination of one railroad's signal accounts indicated an excessive amount of time charged to « cleaning and oiling ». An investigation disclosed that a *routine* had been established years ago and followed without question. A clean switch with well lubricated plates will operate even if the switch is out of surface. And by the same token, an extra pound or so of air pressure, or an extra cell or two of battery, or the addition of switch point rollers, will result in the switch operating even if the plates lack proper lubrication.

Signal faults caused by dirty contacts are rare. Some *routine* cleaning causes faults. Cleaning bands on an interlocking machine will eventually result in lost tension of fingers, or thread from the cleaning cloth cause an open circuit. The zerk fittings on signal apparatus result in excessive lubrication applied by conscientious signalmen on *routine*. A sub-tower or case containing modern signal equipment requires very little *routine* maintenance. Just what is there for a maintainer to do at these locations? If proper records are kept, a meter will tell a signalman the condition of a track circuit much quicker and with greater accuracy than walking track, inspecting and pulling bond wires on *routine*.

Skilled manhours are entirely too valuable and in far too short supply to squander. The signal maintenance man is a very conservative workman. He makes few mistakes, and when he does make one it is generally on the safe side. Any changes to upset his established routine had best be *induced* rather than *imposed*. We often become so accustomed to doing things in a certain way at a certain time, we no longer question the basic purpose of our actions. Blind conformists are found in signaling the same as in all walks of life. Experience indicates that the signal suppliers are much too modest in their recommended time interval to *routine* check their equipment. We are required by law to follow a certain routine of inspections and tests of signal devices, but that is one routine that is outside the scope of this talk.

Training for assistant signalmen.

We have a four-year training program for assistant signalmen. An understanding with the Brotherhood of Railroad Signalmen of America permits us to move the men around the railroad so they may obtain varied experience in signal work.

The men are given on-the-job training with instruction by myself and the assistant supervisors. We also give them a copy of « Railway Signaling and Railway Operations » as well as Signal Section chapters on « Railway Signaling Principles and Practices » which pertain to the work they are doing in a particular six months' period. At the end of each six months, the men are given a written and oral examination covering the work done in this period. The men must pass each of the eight examinations during the four-year training program.

The written examination consists of multiple choice, true and false, and matching questions (match definition with symbol or indication with aspect.) Passing is 70. A man can ask for a re-examination within three months. After two failures he is dismissed as not being able to qualify as a signalman.

I prepare and correct the written examinations. I also give the oral exams. If meter readings, switch adjustments or similar equipment testing or maintenance procedures are involved, I go out in the field with the man and watch him at work. It's real on-the-job training and testing.

Learn about R.F. & P. first.

The training, of course, starts with basic information pertinent to our road, and

progressively becomes more difficult. For example, the first six-months' exam covers the operating time table, rule book, safety rules and graphic symbols. The second exam will cover meter reading, circuit symbols, switch operating sequence, and various types of relay hook-ups. The third exam is more technical, covering the basics of car retarders, C.T.C. or highway crossing protection, depending upon the work performed by the man. As we have one gang working at Potomac yard, we can put an assistant signalman in for six months to give him some retarder experience. We usually finish the training program on carrier equipment. Toward the end, we always bring the men into the drafting room for experience doing circuit work. This program has been very successful, both from the standpoint of the men and our management.

Many advantages when signal maintenance work is done by gangs.

The abolishment of maintenance sections with individual maintainers and the establishment of gangs has many advantages. Here are eleven, with a brief discussion of each :

1) The skill and knowledge of experts are utilized to the maximum. Each man is an all-around signalman capable of working on all types of equipment. We have some men, for example, who are particularly adept at case wiring, or are specialists in switch machine operation and repair. We can take advantage of the skills of these men by assigning them that type of work whenever possible. This doesn't freeze out others from learning from the specialist, because our men generally work in pairs. Thus the non-specialist (in one type of work) can work with and learn from the specialist.

We have the same number of men doing maintenance as we had with maintainers working on sections. Because we are able to utilize them better, we get a higher type of maintenance.

2) Gang maintenance eliminates seniority problems. Under the old system, sections with maintainers were geared to a standard of the least able man. In other words, the bid and seniority requirements for filling vacancies made it essential that the maintenance sections be reduced to the lowest denominator of capacity to accommodate the least qualified man that was eligible to bid on the job. This procedure often resulted in men with exceptional talents being confined to territories where full advantage of their talents could not be utilized and developed. Such an arrangement handicaps the signal department and does not help the man.

3) Adequate forces are available for maintenance. The work schedule is not interrupted by track maintenance, relaying rail, installing switches, etc., that take maintainers' time. When track work is to be done, the foreman can assign men to work with the track forces, while the rest of the gang does signal maintenance.

If one man needs help on a job, the foreman can assign one or several men to help him. A maintainer would sometimes have to wait several days for a maintainer in an adjacent section to be free to help him. With the gang system, adequate forces are available for major repairs, pole line work, small construction jobs, etc., without calling in outside assistance.

4) Supervision, issuing of instructions and training of men is improved and simplified. One reason, of course, is that the foreman can readily get his men together at gang headquarters. An assistant supervisor, signals and communications, is located at Potomac yard and another at Fredericksburg.

Generally, the maintainers worked alone, and the supervisors had to go out along the line to see them. This took a great deal of the supervisor's time, especially if he spent some time instructing the maintainer.

5) Men benefit from the knowledge obtained by construction. Installations of various types of new signal equipment

using new circuits result in better qualified men to maintain this equipment.

6) A minimum number of power tools, meters, special instruments, test equipment and other supplies is required. Fewer tools are needed with gang maintenance than were required with maintainers on sections. For example, only two track motor cars are now used (for the signalmen and track inspectors who patrol the railroad in pairs). Formerly each maintainer had a track motor car.

7) Relief is not required for men on vacation or absent from work on account of sickness.

8) More men are available for correcting signal faults without territory time claims. In case of trouble, the best man available is called. A signalman is sent out, and he may take an assistant, but an assistant signalman is never sent out alone. When trouble occurs, the dispatcher or others in the operating department call the assistant supervisor. If he is not available, the foreman is called. He makes the decision as to which men go out and repair the trouble.

9) A major personal benefit of the gang maintenance system is that members are able to live at home in or near the headquarters. Because our gang headquarters are in fairly large communities, homes, shops, schools, churches and recreation facilities are readily accessible. Generally, the men are home every night. This eliminates the need for camp cars and their attendant sanitary and cooking facilities, as well as a cook.

10) A competitive spirit and urge to learn is apparent in the gangs. As the men usually work in pairs, and often in groups of three or four, they can learn from each other. It is especially beneficial to the younger men as it gives them the opportunity to work with experienced men. A man takes pride in his workmanship because he knows his work will be seen, and he will receive recognition for good work. An esprit de corps or team spirit is created, especially as each gang wants to be the best gang.

11) Work is planned by the foreman with a minimum of routine. In most cases a report is turned in one day, and the work is done the next day — unless it's trouble, which is handled immediately. A big advantage is that no time is wasted. The foreman instructs the man or men on the job to be done, including what is expected.

[625 .162 (73)]

Crossings are safer after 10 years.

(From *Railway Signalling and Communications*. January 1960.)

Fatality rate at railroad-highways grade crossings dropped from 4.4 per-day in 1948 to 3.7 per day in 1957. This was in the face of an increase in motor vehicles from 50 to 67 million. The number of crossings remained steady at about 226 000 through this period. During the last 10 years, over 14 000 of these crossings have been equipped with flashing-light signals only or flashing-light signals with automatic gates. Over twice as many crossings have been equipped with flashers alone as with those equipped with flashers and gates. Also noted in this 10-year period is the increasing tendency of public bodies such as states, cities and towns, to share in the cost of installing new and improved forms of protection at grade crossings.

The trend in recent years has been for more cooperation between railroads and the local municipalities concerning the grade crossing protection problem. The main concern has been to make crossings safer, yet not unduly impede the flow of vehicular traffic. Another problem has been that of replacing watchmen with automatic protection equipment.

An example of such close cooperation to

Ten years of highway-railroad grade crossing protection.

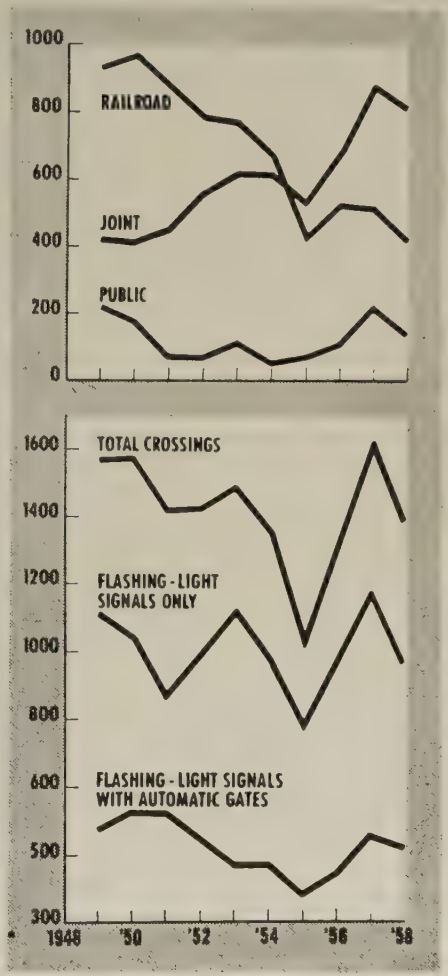
Year	Number of railroads	Total number of crossings equipped	Number of crossings equipped		Source of funds for number of crossings equipped		
			Flashing-light signals only	Flashing-light signals with automatic gates	Railroad	Public	Joint
1958	81	1 380	961	419	423	147	810
1957	83	1 630	1 175	455	520	223	887
1956	88	1 320	984	336	526	105	689
1955	76	1 070	781	289	442	82	546
1954	80	1 364	985	379	686	64	614
1953	86	1 491	1 112	379	772	105	614
1952	94	1 435	986	449	792	81	562
1951	95	1 406	880	526	870	82	454
1950	91	1 573	1 047	526	966	195	412
1949	90	1 571	1 101	470	937	218	416

provide improved protection is the Chicago & North Western, which recently completed a two-year program involving 330 grade crossings in eight states. Studies were made of each crossing concerning street traffic, train movements, switching operations, station stops and other circumstances. Sketches and photographs of the existing crossings were also used. Based upon all this information, a proposal was prepared as applying to each project. Then a conference was held with the traffic engineer or the city council of the municipality in which the project was located. In such a conference, a resolution was prepared to authorize the mayor to sign a joint stipulation which was sent to the state commerce commission. If the commission approved, an order authorizing the project was issued.

If city authorities opposed the proposed improvement, the railroad appealed to the state commission to hold an official hearing. Then a decision and order was rendered by the commission.

In most instances, the city authorities approved of the improved form of protection (gates to replace watchmen or wigwags) proposed by the railroad. Also, in most cases, they agreed that automatic control, which is on the job « round-the-clock », is better and more reliable than manual operation or manual control.

What were once busy streets may now have relatively light vehicular traffic. So that now, most railroads work with city officials in making extensive studies of vehicular traffic flow. In some instances, cities have closed a street with light traffic, where parallel streets exist. This reduces the overall cost of a project and in some instances enables the railroad to install complete automatic controls with speed selection to differentiate between high and low speed trains. Such a project was installed by the Gulf, Mobile & Ohio at Auburn, Ill. Of seven parallel streets crossing the railroad, gates with flashing-light signals were installed at three crossings. Barriers were erected across four streets at the tracks. The C. & N.W., working with the city of Morrison, Ill., installed automatic gates with flashing-light signals, with complete automatic control and speed selection at five street crossings. Barriers were erected at four other street crossings. At Centralia, Ill., the city allowed the Illinois Central to close 12 street crossings with barriers. In addition one grade separation with a highway underpass was constructed; gates and flashers were installed at four streets, and flashers only installed at six street crossings.



Top chart: sources of crossing funds. Bottom: type of protection installed.

In some areas, street traffic as well as rail switching moves have been reduced and changed in nature. Manual gates, operated part time, have been in service for 60 years or more at some crossings in industrial areas. But modern flashing-light signals with automatic control in service round-the-clock are better protection now. This was done at nine crossings in one area of Chicago, Ill.

Speed selection has made complete automatic control practical. An objection to automatic control in the past has been that, in some instances, such as during switching moves, gates are down and delay street traffic, when no train movement over the crossing is imminent. To overcome this objection, most railroads install selective speed control schemes, time distance cut-outs, restarts, etc. The C. & N.W., for example, improved protection at nine crossings in Wheaton, Ill. Speed selection controls utilize timing sections for speed ranges as follows : 1) above 65 m.p.h., 2) 65-52 m.p.h., 3) 52-37 m.p.h., 4) below 37 m.p.h. When station stops are involved, speed ranges also include 37-28 m.p.h. and 28-17.5 m.p.h. In addition to these speed selection controls, push-buttons at the crossings enable switching crews to raise gates if they stop short of the crossing and are not in a timing section.

In some instances railroads have changed their schedules so that switching by local freights is not done during periods of peak vehicular traffic. At Carroll, Iowa, where automatic gates had been in service for years, at three street crossings, one reason for supervisory manual control was to clear the gates for street traffic when through freights were stopped to set out or pick up cars. By establishing rules and fixed wayside signs designating the points beyond which standing portions of trains must be left, the automatic controls were revised so that no further manual control was required.

As seen from the graph, the number of crossing projects paid for by joint railroad and public funds has been increasing over the last 10 years. With the tremendous increase in vehicular traffic, municipalities have recognized the need for improved protection and, more important, the responsibility for sharing installation costs with the railroads. Several states, such as Illinois, have long recognized the need for improved protection and have been prompt to supply state funds to help pay for these projects.

C. & N.W. experience from their two-year, 330-crossing program, has been that where the form of protection was improved in character, for example, gates to replace wigwags, the local or stade funds at certain locations paid part. At De Kalb, Ill., automatic gates were installed at six crossings to replace manually controlled wigwags. The total estimated cost was $ 203 839, of which $ 89 241 came from government funds. At one crossing in Des Plaines, Ill., automatic gates were installed to replace flashing-light signals. The total cost was $ 12 840, of which $ 11 072 was paid by government funds.

In recent years, the railroads have contended that the public as highway users should share in the cost of maintaining crossing protection equipment. One of the first states to recognize this responsibility has been Virginia. The sharing of maintenance costs applies to all « automatically operated gates, wigwag signals and other electrical or automatic crossing devices at highway grade crossings outside of cities and incorporated towns ». The railroads work out an agreement with the State Highway Commissioner. If unable to come to an agreement on the maintenance costs, the railroad can petition the Virginia State Corporation Commission for a hearing, after which the Commission decides the issue.

Just recently the North Carolina legislature passed a law requiring the State Highway Commission to pay one-half the costs of maintaining railroad grade crossing protection equipment. The law applies to the more than 500 signals now in the state (previously maintained by the railroads) and to any that will be instal-

led in the future. It is estimated that such maintenance costs will be over one-quarter of a million dollars a year.

In the years 1949-1958, flashing-light signals only were installed at 10 012 highway-railroad grade crossings, according to figures furnished by the railroads to Railway Signaling and Communications each year. Flashing-light signals with automatic gates were installed at 4 228 crossings. Sources of funds in this 10-year period were as follows, according to number of crossings equipped : railroad-6 934; public-1 302; joint (railroad and public)-6 004.

Two major factors contributed to the growth of crossing protection installations over the last 10 years. One was the increase in motor vehicles. The second was the return on investment that can be realized from highway crossing protection equipment. The C. & N.W. will realize a $ 2 million saving every year in wage costs by retirement of crossing watchmen and gatemen. This saving is approximately 59 % annually on the capital invested by the road. At Kenilworth, Ill., the C. & N.W. spent $ 29 375 to install automatic gates to replace manual gates. The wage savings is $ 17 358 annually, which is 68 % on the cost every year.

625 .172 (73)]

Inspector's car speeds yard operation.

RF & P uses track car to expedite train inspections; it makes possible on-the-spot decisions by supervisor.

(*Railway Locomotives and Cars*, April 1960.

Assignment of special track for use by track car has expedited the inspection of important freight trains at the R.F. & P. Richmond yard.

New car inspection and repair service techniques have enabled the Richmond, Fredericksburg & Potomac to reduce yard delays at Richmond, Va., by at least 65 %. Assignment of one yard track for use by a special car foreman's track car makes it possible to get maximum utilization of manpower, materials, and tools while simultaneously keeping train detentions to a minimum. It makes possible direct supervision of inspections and repairs which go on along the mile-long freights which the R.F. & P. operates over its line.

Interchange inspections on manifest trains, including repairs, such as rebrassing, and operations, such as the closing of hopper doors, are frequently completed in as little as 30 min with trains of up to 125 cars. From Richmond, these trains then move over the 107-mile R. F. & P. main line to Potomac Yard in Alexandria, Va., where they are classified for movement to northern cities.

Because there is almost no classification necessary on northbound trains, blocked as they are by the A.C.L. and S.A.L. at points south of Richmond, the R.F. & P.'s Richmond car inspection operation is comparable to that performed at intermediate terminals on longer railroads. When it comes to the actual mechanics of this operation, the road has displayed real ingenuity.

Foreman can make rolling inspection of train from operator's position on track car. Walkie-talkie enables him to contact yardmaster.

The R.F. & P. purchased a Fairmont A-3 gang car, which has now been fitted with running boards, tools, materials, floodlights and radio to make it a rolling car foreman's office, toolroom, and stores facility. During those periods of the day when northbound manifests follow one another into Richmond yard, this track car makes it possible for the car foreman to move his men and tools from operation to operation with minimum delay. At the same time, this arrangement makes possible direct supervision and on-the-spot decision by the foreman.

While the goal of « spot » car repair systems set up by many railroads recently has been « taking the work to the man », the theme of the R.F. & P. Richmond operation might be summarized as « taking the man to his work ». This does not mean that walking is eliminated; the R.F. & P. still gives trains the scrupulous on-the-ground inspection possible when pairs of inspectors simultaneously walk and check both sides of a train. It does mean that inspectors are delivered by the track car at intervals along a train so that inspections begin at several points on an arriving train almost simultaneously.

Prior to the arrival of a train, the yardmaster tells the foreman of its arrival, length, and track assignment. This can be done over the yard speaker system, or on the walkie-talkie radio which the track car carries. The standard procedure is to assign one yard track almost permanently to the car department and to bring all incoming manifest trains in on the two tracks which flank this one. The track used by the track car is adequately protected so no switching moves can be made over it.

With up to eight car inspectors available, the foreman assigns segments of an incoming train to pairs of these inspectors. The car repair facilities at Richmond yard are at the south end and an incoming northbound train pulls past this point. It is here that the car foreman usually has his inspectors board the track car. With a 120-car train arriving, he will leave the first pair of inspectors at the point where the caboose can be expected to stop. He will then proceed north along the train as it pulls in, giving it a quick visual inspection and leaving pairs of inspectors

Folding running boards provide location from which inspector can check trucks and underframes of cars while track car moves along.

Special lock protects tracks used by inspection car. Other end of mile-long yard track is protected by towerman who operates switch.

at 30-car intervals. When the train finally stops, inspections can begin at four points along the length of the train.

If one team of inspectors finds a car which needs a new brake shoe or other work which can be done without cutting the car out, they stop their inspection and go ahead with the repairs. This means that other men will then complete the inspections originally assigned to the first pair. Stocks of materials, such as brake shoes, brasses, pins, and keys, are stocked in material boxes along the track and are also carried on the track car.

When the job requires materials, tools, floodlights, or a decision by the foreman as to whether a bad-order car is to be repaired in the train, inspectors signal the foreman who comes to the point on his track car. If it is necessary to make a set-out, the foreman calls the yard office with his walkie-talkie. Early detection of bad orders frequently enables the switcher to cut the car out while it is changing cabooses, or before the R.F. & P. road locomotive has been coupled to the train.

Once inspection has been completed, the track car can be used to bring inspectors back to the car repair track. They can then go back to work on bad-order cars, or be ready for assignments on other incoming trains, or on cuts of cars which are delivered to the yard and inspected in more conventional fashion. The track car is frequently used to move men and tools back and forth through the yard, even though through freights are not involved.

Utlization of a track car as the R.F. & P. has done has the following advantages:

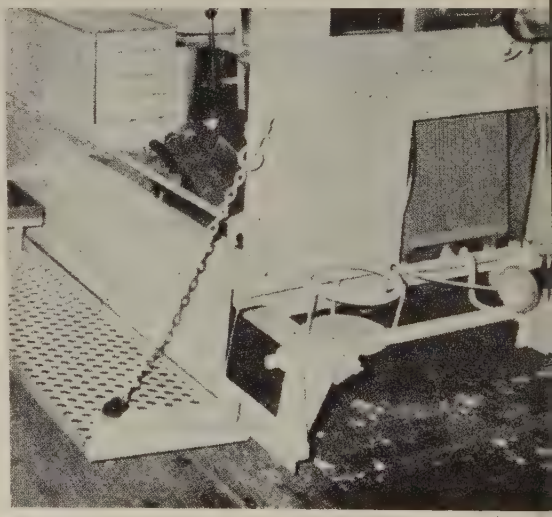
it eliminates walking to widely dispersed assignments, increasing productive time;

it makes possible close supervision of these dispersed operations and simplifies their coordination;

it provides a mobile radio station which makes it unnecessary for each inspector to carry a walkie-talkie;

it provides a quick way to transport tools and materials, as well as men, over a wide area;

it reduces train detentions which assists in holding and gaining traffic. For a short road like the R.F. & P., per diem charges can be greatly reduced.



Lights, brackets, racks and running boards were installed on Fairmont gang car by R.F. & P.

[625 143]

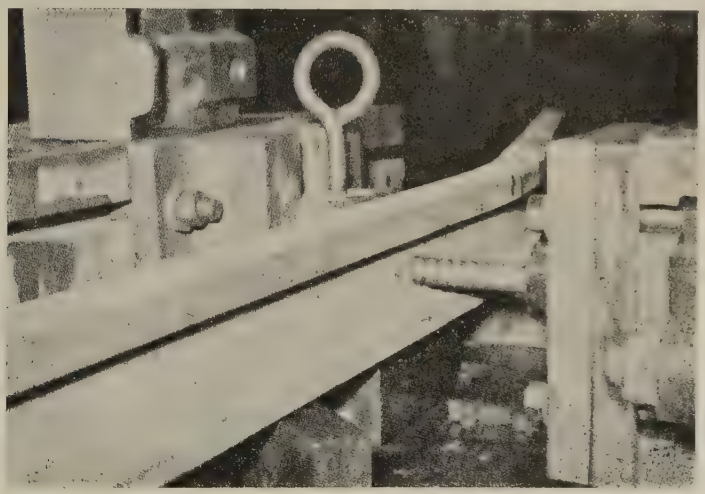
Work-hardening bolt holes in rail ends.

A method of countering star cracking aggravated by high shear stress in rail fishbolt holes,

by S. Wise, M.I. Mech.E., A.I.M.

(*The Railway Gazette*, April 29, 1960.)

Although relatively few rail failures occur on British Railways, it has been the custom for several years now to prepare detailed statistics on those failures which do occur. This analysis of rail failures has shown that the most frequently occurring type of failure is that classified as « 4 d » which takes the form of radial cracking from one or both bolt-holes known as star cracking as shown in the illustration overleaf. The cracks follow a path at 45° to the axis of the rail; there are usually two from a hole but quite often four are found, spaced at roughly 90° from each other. These cracks are potentially dangerous if allowed to grow undetected, because if the two upper cracks run into the head of the rail complete separation of part of the running surface about 8 in. long may occur.



Work-hardening process in operation on wing rail.

High stress concentration.

The Research Department of British Railways has paid very considerable attention to this form of failure. Analysis of the stress system in the rail shows that the cracks are due to high shear stress in the web aggravated by the presence of

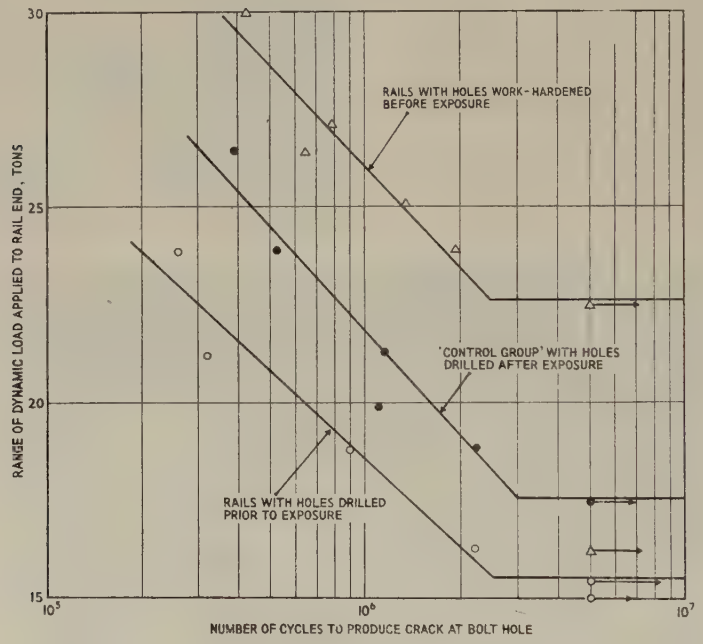
the fishbolt hole which introduces a stress concentration factor of four at the surface of the hole.

The use of short-gauge-length electrical-resistance strain gauges has made it possible to measure stresses at the bolt holes in rails in the track during the passage of trains. Many thousands of such measurements have now been made on different sites and under a variety of different forms of traction, and much useful information has been obtained.

There is evidence to suggest that increased stresses are induced in the bolt holes by the passage of locomotives with relatively small driving wheels, so that any method of increasing the ability of rails to resist star cracking becomes a matter of considerable importance.

Fatigue tests.

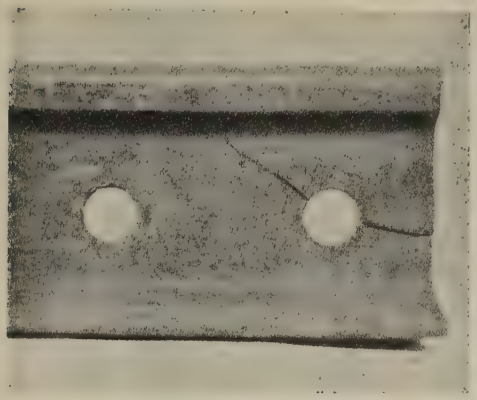
While the field stress measurements have been in progress, fatigue testing of sample rails drilled with fishbolt holes has been carried out in the laboratory; more than 100 such tests have been made. The star cracking type of failure has been reproduced in the fatigue testing machine and the fatigue strength of the drilled rail in the new and corroded state established. Various methods of improving the fatigue strength of drilled rails have been tested; these have included improving the surface finish of the hole, reduction in hole diameter (as practised by the French National Railways), and the use of a thicker web f.b. rail. The greatest improvement has been obtained by work-



Results of fatigue tests on 109-lb. f.b. rails after 12 months' exposure to corrosion in industrial atmosphere.

hardening the surface of the holes, by initially drilling undersize followed by broaching or drifting with a spherical tool to the required size.

So far the initial reduction in hole diameter has been 3/64 in. (from 1 3/16 in. to 1 9/64 in.) for 109 lb. per yd. f.b. rail; the work hardening has been done in a press using tools of the type illustrated, and has resulted in increasing the fatigue strength of the rail by 50 %, a figure which is maintained after exposure to corrosion. Results of these tests are shown in the curves on the preceding page.



Radial cracks forming a Class « 4 d » failure in f.b. rail.

Trial lengths of rails with work-hardened bolt holes were laid two years ago in Dove Holes Tunnel, London Midland Region, and the Severn Tunnel, Western Region, where, because of the wet conditions which prevail, the life of rails is very short, and the corrosive influences present may accelerate the occurrence of star cracking at the rail ends. The rails have since been removed and shortly will be subjected to fatigue tests to determine how well they have withstood service under the severe conditions which obtain in these tunnels.

Rails laid in switches and crossings are also susceptible to star cracking failures and for this reason it has been decided to apply the work-hardening process to crossing rails. Experiments have been made at the works of Taylor Bros. (Sandiacre) Ltd. with a large crossing for Derby Station, London Road Junction, fabricated in 95 lb. b.h. rail. All the holes in these rails, with the exception of stretcher-bar holes in the switch blades, were work-hardened, including those for driving-fit bolts. For these the tool was specially designed to give a finished bolt size correct to within ± .001 in. after allowing for elastic recovery in the hole.

No trouble was experienced in work-hardening any of the holes, including those where the axis is inclined to that of the rail. Several hundred holes were treated without noticeable wear of tools.

Tools of the type used for work-hardening fishbolt holes.

[624 .63 (73)]

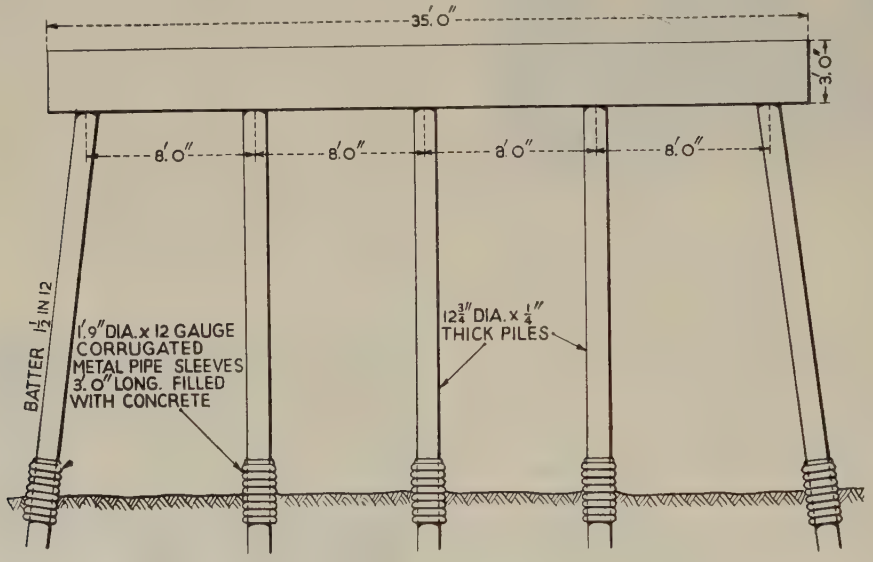
North American road overbridge design.

Claimed to be a durable and cheaply-maintained structure.

(*The Railway Gazette*, February 5. 1960.)

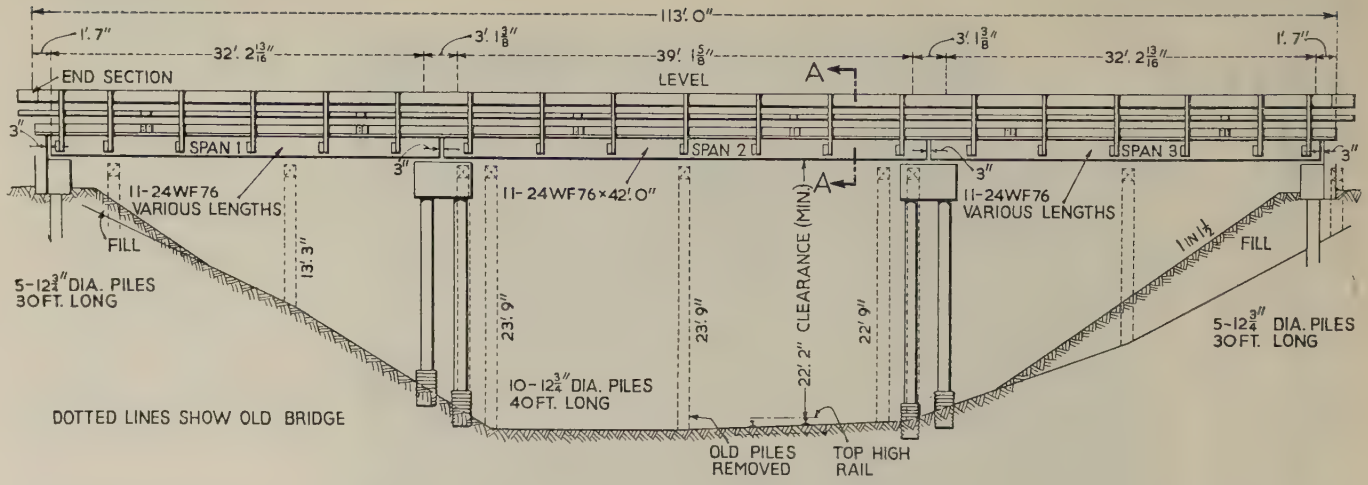
The double-track main line of the subsidiary of the Canadian Pacific Railway, the Soo Line, passes under Silver Lake Road just to the east of the city of Minneapolis, in a rapidly developing area. The overbridge concerned has hitherto consisted of a timber-trestle structure with wooden plank decking 20 ft. wide, and steeply inclined approach embankments. It had become very costly to maintain and its piles were posted and needed replacement. Moreover, loads crossing it were limited to 10 tons, whereas the road traffic, now heavy and fast, serving the increasing population, demanded a much stronger, wider and more suitable bridge.

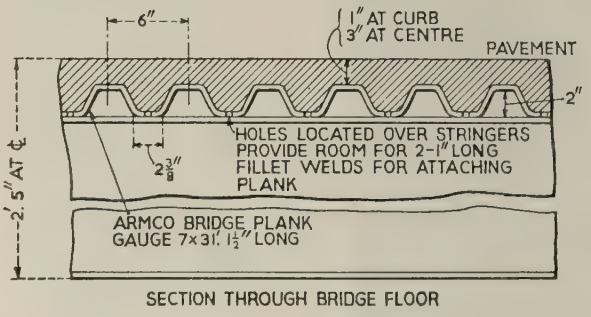
Consequently, the railway administration in consultation with the highway authority has designed and built a new overbridge for H-20 vehicle loading, 113 ft. long and 30 ft. wide between curbs. It has a 39 ft. central span flanked on each side by a 32 ft. approach span, all three spans on the level. The highway authority has built up the approach banks with easy gradients to suit the new bridge.



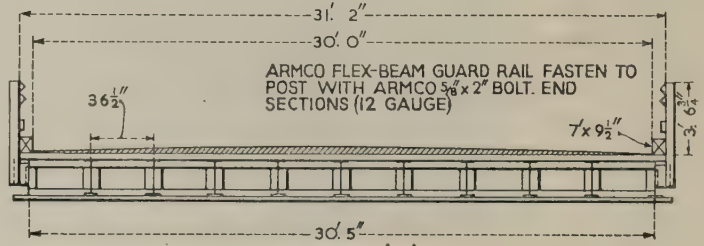
View along bridge centre-line of one of the Armco pipe line-trestle bents.

The superstructure of each of the three spans consists of eleven 24 WF 76 R.S.B. stringers spaced approximately 3 ft. apart carrying 7-gauge trapezoidal transverse Armco steel corrugated sheets 2 ft. wide and cut to 31 ft. 1 1/2 in. lengths to form the decking. The corrugated sheets are secured to the R.S.Bs. by fillet welding,




6"
1" AT CURB
3" AT CENTRE
PAVEMENT
2"
HOLES LOCATED OVER STRINGERS PROVIDE ROOM FOR 2-1" LONG FILLET WELDS FOR ATTACHING PLANK
2 3/8"
2'. 5" AT ℄
ARMCO BRIDGE PLANK GAUGE 7×31'. 1 1/2" LONG

SECTION THROUGH BRIDGE FLOOR

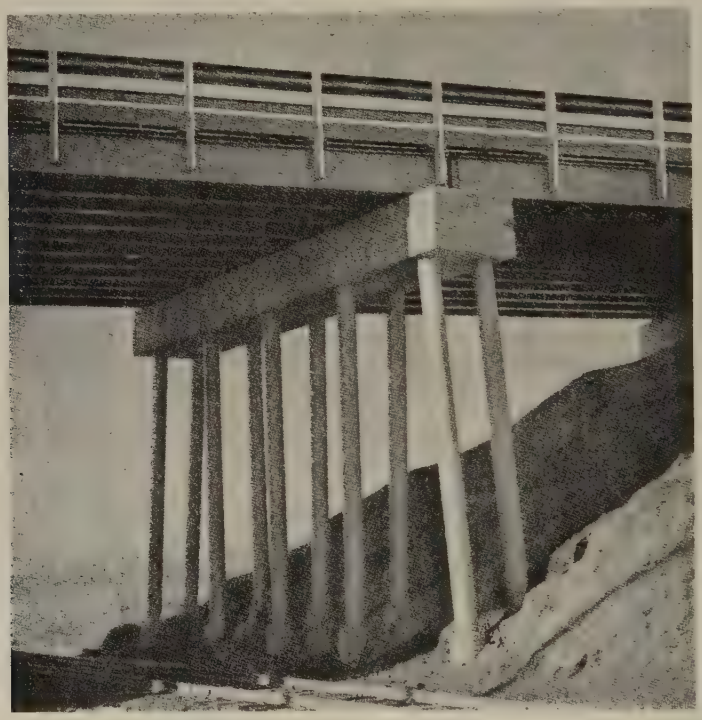


SECTION A.A.

Above: side elevation of completed bridge. Below: sections through decking.

two 1-in. welds being made through holes in the troughs over each of the beams. The troughing of the sheets was filled with hot plant mix asphalt spread and compacted in layers. The asphalt was carried up to minimum depths of 3 in. in the centre of the 30 ft. roadway and 1 in. at the curbs.

rows of five in each pier are 40 ft. in length driven into the soil about 20 ft. In both piers and abutments the outer piles were driven on a batter of 1 1/2 in. to 1 ft., the remainder being vertical. After driving, the piles were filled with concrete having reinforcement tied in with



View of pier with corrugated metal collars at ground level filled with concrete to protect piling from corrosion.

The guard or hand railings are of Armco Flex-Beam held by angle-posts 6 ft. 3 in. apart.

The superstructure is supported on R.C. capping over piles; the concrete block abutments are each carried by five piles, and the pier caps are 3 ft. deep and 30 ft. long and each rests on ten piles. All the piles are Armco welded steel pipes 12 3/4 in. outside dia. and 1/4 in. thick. Those under the abutments are 30 ft. long, and the two

that in the concrete caps. As a protection against corrosion the pier piles are surrounded by 12-gauge corrugated pipe sleeves at ground level 21 in. in dia. and 3 ft. long filled with concrete.

Apart from painting, maintenance is expected to be light and the cost of this bridge is stated to be about £ 14 130 or £ 4 2 s. a sq. ft. of road surface. It is capable of carrying the heavy and fast vehicular traffic of today.

[625 .14 (42)]

Blanketing and drainage at Lapworth, Western Region.

Enlargement of cess and installation of pre-cast channel drain ; retaining wall of 6-in. to 9-in. stone in Weldmesh crates.

(*The Railway Gazette*, August 21, 1959.)

Completed retaining wall, showing concrete channel drain.

Blanketing and drainage work was carried out recently at Lapworth, British Railways, Western Region, in a deep clay cutting which was showing signs of minor slips in one or two places, whilst a number of springs near the toes of the slopes discharged a continual flow of water on to the cesses.

Crumbling dry stone wall.

The bottom of the cutting slope adjacent to the down relief line was supported by a dry stone wall which was crumbling badly because of the earth pressure behind it and the constant flow of spring water through it. The cess at this point was extremely

narrow, with clay up to the bottom of sleeper level making it almost impossible to maintain properly the top or correct cant on the relief line.

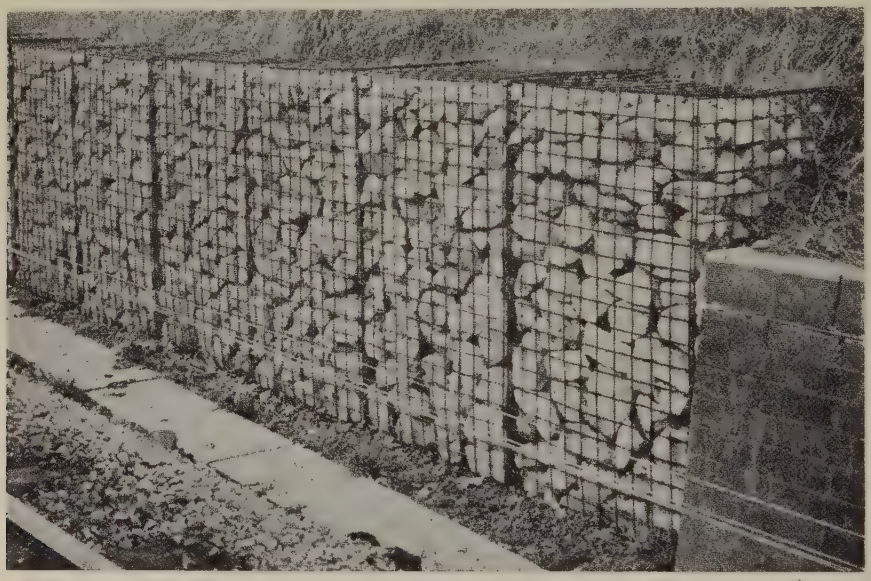
Diversion of spring water.

Several improvements were necessary. The most important was to intercept the spring water and divert it away from the permanent way. This was achieved by lowering and widening the cess to as near the standard dimensions as possible and installing a pre-cast concrete channel drain, using Taunton standard units. To carry out these measures the toe of the slope had to be cut back and a new retaining wall provided.

Gabion wall.

The decision to build a gabion wall was influenced by several factors. First, from an economy point of view, the stone in the existing wall could be used to provide part of the filling for the gabions. Second, speed of erection was most important because of the unstable nature of the slopes, especially if the weather had been wet. Once the Weldmesh crates had been positioned on a 6-in. bed of concrete they could be filled with stone reasonably quickly even with unskilled labour.

Finally, it was essential that the gabion wall, besides supporting the slope, should allow the spring water to pass freely through it into the channel drain.



Weldmesh crates filled with stone.

Ten chains of wall were dealt with in this manner, using B.R.C. Weldmesh crates 2 ft. 9 in. square by 57 in. and 48 in high filled with 6 in. to 9 in. stone. To complete the work the permanent way was deep re-ballasted throughout and the formation graded to the channel drain.

The work was carried out under the direction of the Chief Civil Engineer of the Western Region, Mr. M. G. R. Smith, M.B.E., B.S.C., M.I.C.E.

[656 .22 (73)]

Ride tests seek loading data.

(*Railway Age*, November 23, 1959.)

Ride-analysis train consisted of engine and caboose for train crew, a combination car for the test crew and instruments, and two gondolas with special staging permitting 70-ton rail loads to be carried at varying centers of gravity. This test run was made with a 70-in. C.G. Car near combo has long-travel springing; car near caboose has 1 5/8-in. spring travel. Tests were made on D.L. & W. main freight line.

A new system of ride analysis has been developed by A.A.R.'s Research Center in Chicago. Basically similar to the inertial guidance systems used to stabilize missile platforms, the A.A.R. device measures and records roll and pitch at selected locations on a moving car.

A series of test runs charting characteristics of differing centers of gravity has been completed this month. The test runs were made on the main freight line of the Delaware, Lackawanna & Western between Hoboken and Denville, N.J. (R.A., Nov. 16, p. 7). Figures on vertical and lateral acceleration and displacement for varying locations and loads were obtained.

To be used in T.O.F.C. studies.

« We are applying this method of measurement to some of our clearance studies », says W. M. Keller, A.A.R. vice-president of the research department, « and we expect to use it in connection with piggyback shipments ».

These data will be used in studies of clearance requirements, the effect of car motions on loads, and ride characteristics related to design of trucks, springing and track.

The new system for measuring ride characteristics was developed by the Research Center laboratory staff, under the supervision of Director of Engineering Research G. M. Magee. Randon Ferguson, A.A.R. electrical engineer, was largely responsible for initiating the new method of measuring absolute vertical and lateral displacements simultaneously. Mr. Ferguson was in charge of the test trains.

The test equipment consisted of accelero-

meters and gyroscopes mounted in two test cars, from which they sent test data in the form of electrical impulses to recording instruments. Two D.L. & W. gondolas were used for test cars. A D.L. & W. combination car, in which the instruments were mounted, carried the test staff.

The two gondolas were provided with timber staging to permit loading approximately 70 tons of rails in each car at any of several different centers of gravity. The first test run was made with the center of gravity high. Successive runs lowered the center of gravity, and the final test measured motion under no-load conditions. One gondola was equipped with long-travel springing (3 11/16 in.) for a soft ride; the other had short-travel (1 5/8 in.) springing.

Accelerometers to measure vertical and lateral acceleration and displacement were set up. Each car had two lateral accelerometers, one mounted high and one low, to measure possible differences in sideward motion at the top and bottom of the load. A single vertical accelerometer was mounted low on each car. These were all of the Wheatstone bridge type, providing electrical signals according to the varying resistance set up by the movement being recorded.

Signals from the accelerometers were amplified and filtered (to take out unrelated high-frequency vibration) and fed to two recording oscillographs, one for the long-travel spring car and one for the short-travel car. Impulses from the accelerometers were also fed to an oscilloscope for continuous viewing of the pattern of movement. A 35-mm camera attached to the oscilloscope was set to record the scope screen automatically at one-second intervals. The oscilloscope was switched from car to car at selected points en route.

What oscillographs recorded.

Each oscillograph had pens recording six separate items: vertical acceleration, lateral acceleration, vertical displacement, lateral displacement on the low accelerometer, lateral displacement on the high accelerometer and a reading from a gyro unit showing the degree of body roll caused by track curvature. A speed recording tape and a speedometer were also hooked up, and test assistants recorded speed on curves and in other special conditions on the oscillograph roll. Milepost numbers were also added on the oscillograph and speed recorder charts.

The tests were held between milepost 5 out of Hoboken and Denville (milepost 34). On two of the runs, the train continued past Denville over the old main line to Washington, to gather data on conditions on secondary track. Outbound tests were run at slow speed: 5-20 m.p.h. Inbound, the tests were run at speeds up to 60 m.p.h.

Three stops were made en route to measure static lean on curves with respective superelevations of approximately 2 1/2 in., 4 in. and 6 in. These static figures will be correlated with the dynamic data. Individual railroads will eventually be able to figure dynamic results for particular types of equipment by making static lean tests and applying conversion figures.

NEW BOOKS AND PUBLICATIONS.

[625 .14 (02]

Oberbautechnik und Oberbauwirtschaft (*Technique and maintenance of the superstructure*), by Ministerialrat Dr.-Ing. Habil. G. SCHRAMM, Oberbaureferent Deutsche Bundesbahn.— One volume format Dines, A5, 330 pages of text, 28 pages of references, 22 tables and 210 illustrations. — 1960, Otto Elsner Verlaggesellschaft, Schöfferstrasse, 15, Darmstadt (Price : DM 30.—).

For the first time in German technical literature, we have in a single volume a description of the superstructure and the regulations for its maintenance.

The first part (218 pages) gives the scientific bases for making and establishing the track, which include in particular the results of research work and trials carried out in Germany and abroad; this deals in particular with questions relating to the stressing of the track, concrete sleepers and long welded rails. In connection with the rails, sleepers, accessories and ballast, the author discusses both the design and the method of manufacture and utilisation. The rail fastenings used in the most representative countries are carefully described and analysed. The main features of the design of points are clearly described, and a special chapter is devoted to the control measures to be carried out on the line by the most up to date processes.

The second part (112 pages) deals with the general principles and organisation of the maintenance of the permanent way as well as the drawing up of the annual programmes. The work is set out in such a way as to be universally applicable, without regional distinction; however, examples taken from actual D.B. practice give some idea of the size of the operations considered. In the chapter dealing with the carrying out of the work, much space has been given to mechanisation. To conclude, the question of the organisation of the work in the permanent way depots is gone into, as well as the principles to be followed in getting in supplies.

This book, which is well planned and pleasant to read, is not only an invaluable didactic work intended for use in the technical schools, but will also be of great service to experienced technicians. Although the 22 tables appended, covering various data, are based almost exclusively on the practice of the German Federal Railways, they also include much information which could be used directly or for purposes of comparison on railways in other countries; this remark applies in particular to the machines used, which are almost internationalised types.

The bibliography includes some 400 references collected from the technical press to which the author refers on many occasions so as not to make his own reports unduly long. In addition, the advertising matter, collected together at the end of the book, directly covering the material dealt with, is aso of the greatest interest to the reader.

A.J.

] **625** .14 (02]

LAMALLE (Ulysse), Civil Engineer (Mining), A.I. Lg. Honorary General Manager of the Belgian National Railways, Emeritus Professor of the Railway Operating Course at the University of Louvain. — **Railway Operating.** Volume III : **The permanent way.** Part I : *The ballast — The sleepers — The rails — The track installations — Slewing and translatory motion.* — 3rd edition. — One volume (8 1/4 × 9 7/8 in.) of 288 pages with 370 figures. — 1960, Librairie Universitaire Uytpruyst, publisher, 10, rue de la Monnaie, Louvain.

M. LAMALLE has brought out the third edition of Volume III, devoted to the Permanent Way, of his important work on Railway Operating.

Based on the same general lines as the previous edition, which was published in 1951, this book studies in turn the various constituents of the permanent way : the ballast — the supports for the rails, sleepers or longitudinal supports — the rails and the track installations.

In each case, the author goes into the history of the question, describes the successive solutions adopted, discusses the advantages and drawbacks, and stresses the evolution that has occurred during the last few years.

We may mention in this connection the description of the prestressed concrete sleepers used by the D.B. and on the S.J., and the definition of the U.I.C. rail profile.

The studies and results of experience which are of capital importance as regards the way the track will stand up to service are also mentioned, in particular in connection with the thermal equilibrium of rails, ultrasonic tests to find internal defects in rails and undulatory wear.

The development of long welded rails is also the subject of a very full documented report.

M. LAMALLE deserves our gratitude not only for preparing this minutious inventory of the processes and new technical methods perfected in connection with the permanent way, a field where such great progress has been made during recent years, but also for having integrated all these facts in his usual masterly way within the framework of a Railway Operating Course, which is already so well known as to need no further recommendation, thus forming a source of information of particular value for all those interested in railway science.

R. S.

] **656** .2 (4)]

Vereintes Europa auf der Schiene (*A united Europe through the medium of the railway*). — Published under the auspices of Professor Dr. jur. H.M. OEFTERING, Chairman of the Management Committee and First Chairman of the Deutsche Bundesbahn and Dipl. Eng. H. GEITMANN, Chairman of the D.B., with the collaboration of numerous German and foreign authors. — 1958-59, Darmstadt, Otto Elsner Verlagsgesellschaft. — Format DIN A 4, 240 pages with numerous illustrations.

This publication, issued under the auspices of European co-operation, deals with the great financial, technical, commercial and legal problems which confront the Railway Administrations.

Here is collected together under the signatures of notable personalities of the transport world, a great number of notes showing the present position, stressing the progress realised and pointing out the objectives still to be attained in the various fields of railway activity.

Financial, general administrative and rating problems are dealt with first of all. These are introduced in two notes written by Professor Dr. jur. H. M. OEFTERING, Chairman of the Management Committee and First Chairman of the Deutsche Bundesbahn, Chairman of the U.I.C., and Mr. Ir. E. DESORGHER, Assistant Honorary General Manager of the S.N.C.B. and Chairman of the IIIrd Commission of the U.I.C., which show the need for effective government action in the co-ordination of transport, in order to put the railway on a sound basis, whilst enabling it to modernise and rationalise its equipment.

The following articles dealing with technical problems, show very strikingly the efforts already made in this direction by the railways: development of electric and Diesel methods of traction, automation, improvement of the stock, introduction of better international services. In all these questions, the effectiveness of close international co-operation, not only between the Railway Administrations, but also between the builders of railway rolling stock, is clearly brought out.

Finally, an article reporting the achievements and objectives of the O.S.Sh.D. (Organisation for Railway Collaboration) stresses the close co-operation already existing for several years between the Railway Administrations of Eastern Europe and certain Asian Administrations. R. S.

[385 (08 (494)]

Management Report of the « Union d'Entreprises Suisses de Transport », for the year 1959. — One brochure (8 1/4 × 11 1/2 in.) of 78 pages, illustrated. — 1960, Union d'Entreprises Suisses de Transport, Bundesgasse, 28, Bern.

The « *Union d'Entreprises Suisses de Transports* » has just published its report for the year 1959.

Examining first of all the overall results for the year, the report concludes that there has been a slight improvement compared with the year 1958, both in the field of freight transport and passenger transport. However, it is advisable to wait for the publication of the official statistics to express an accurate statement on the situation.

It then studies the repercussions of the decree of the 19 December 1958 on railway accounts on the presentation of the operating accounts of the undertakings. This decree introduced the idea of « the principle of the gross accounts » and includes in the operating account, the ordinary sinking fund charges and the total amount paid by the Confederation in return for the obligations laid on the railway in favour of the general economy. As a result, there are however certain difficulties in making a comparison with the pre-1958 and subsequent statistics, and such comparisons must only be made with the greatest caution.

The main technical renovations carried out by the various undertakings, as well as the rationalisation problems with which they are faced, are also the subject of a general report.

The report ends with a detailed statement of the current activities of the Union, in the legal, technical and tariff fields, as well as the systems of operating and the markets.

It concludes by stressing that if the law of the 20 December 1957, which made provision for assistance from the Confederation and the Cantons both as regards technical improvements and the covering of deficits has led to a certain improvement in the financial position of the undertakings, it also imposed upon them the obligation to take steps to make their operating more economical, by means of a rational system of management, and to increase their output, and it suggests that these general problems should be studied by the Union itself. R. S.

[385 (09 (44)]

Activité et productivité de la S.N.C.F. en 1959 (*Activity and Productivity of the S.N.C.F. in 1959*). — Published by the French National Railway. — One brochure (8 1/4 × 10 1/2 in.) of 32 pages, with maps, diagrams and tables.

The S.N.C.F. has just issued a pamphlet giving the main results of its working during 1959.

In the preface, Mr. DARGEOU, General Manager of the S.N.C.F., stresses the increased productivity of the S.N.C.F., the result of the rationalisation and modernisation of all sorts so tirelessly carried out. He sees therein the justification for the policy pursued by the S.N.C.F. for several years and the capital investments agreed to. He concludes by stressing the determination of the S.N.C.F. to continue to carry out its modernisation programme, which will enable it to absorb the increasing amount of traffic to be expected as a result of the evolution of the situation towards a new expansion of French economy.

The decline in freight traffic, which began in 1958, was intensified in the first months of 1959, but the situation then improved, so much so that taken as a whole, the 1959 traffic was on the same level as that of 1958. In the case of the passenger traffic, the 1959 traffic was more or less the same as that of 1958.

The staff has been reduced slightly, whereas its productivity (traffic units per working hour), which declined slightly in 1958, once again reached the record level of 1957 (110.4).

The traction conversion, based mainly on the development of electrification, is always the major item in the modernisation programme of the S.N.C.F. Two hundred and eighty-three kilometres of lines were electrified in 1959, either with industrial frequency single-phase or with D.C. The traffic on the electrified lines by the end of 1959 amounted to 53 % of the total traffic, electric traction thus coming for the first time top of the list compared with steam traction and Diesel traction.

However, dieselisation has been continued and extended to the shunting services and small lines, average lines and even to the main lines. The stock of Diesel units has been increased in particular by the first combined 1 300-1 400 HP locomotives.

These changes in traction have resulted in an increase of about 11 % compared with 1958 in the power productivity of the S.N.C.F. (number of traffic units assured by each kilogramme of coal equivalent).

The fixed installations on their side have been the object of numerous improvements, thanks to the introduction of more modern techniques, in particular in the case of the safety installations and telecommunications. The permanent way is also being modernised very rapidly by the use of long welded rails, which by the end of 1959 had been laid on nearly 5 600 km.

In the operating field, mention must be made of the increase in the average speeds of the passenger trains, the creation of new services (the replacement of railcars by electric trains on the Paris-Lille line had the effect, in particular, of increasing the traffic on this line by 24 % compared with 1958), the increase in the number of sleepers and 2nd class couchettes available, improvements as regards the regularity and speed of the freight trains.

The pamphlet is completed by a series of diagrams, maps and statistical tables, showing the activities of the S.N.C.F. as a whole.

R. S.

M. WEISSENBRUCH & Co. Lid.
Printer to the King
(Manag. Dir.: P. de Weissenbruch,
238, chaussée de Vleurgat, XL)

PRINTED IN BELGIUM

Edit. responsible: P. Ghilain